BUILDERS OF EMPIRE

FLOYD L. DARROW

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Builders of Empire

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Courtesy of the Union Pacific System

Driving the golden spikes at Promontory Point, Utah, celebrating the union of the Union Pacific and Central Pacific Lines

BUILDERS *of* EMPIRE

BY

FLOYD L. DARROW

Author of

"NEW WORLD OF PHYSICAL DISCOVERY"

"MASTERS OF SCIENCE AND INVENTION"

LONGMANS, GREEN AND CO.

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DARROW

BUILDERS OF EMPIRE

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FOREWORD

BUILDERS OF EMPIRE has been written for the boys and girls of America. Its pages speak of the lives and deeds of some of the men who have helped to make possible this vast heritage of opportunity which we call American civilization. That heritage, together with the great natural wealth and free spirit of this broad land, make the empire to which we refer in the title. Of course, empire building in America began long before the leaders of whom we are about to tell came upon the scene, but it is the story of the more recent conquests which we now wish to give. And a wonderful story it is! Here we shall find rugged pioneers of the mountains and the great open spaces, railroad builders, engineers, leaders of industry and big business, inventors and scientists jostling one another in the feverish struggle to build a nation here in this western world. In practically every instance, these were men of vision. The possibility of some great achievement lured each one on. Peary wished to conquer the North Pole, Lindbergh sought to span the ocean by way of the air, Walter Reed pictured an island free from the

yellow jack, Bell dreamed of talking over a wire, Goethals believed he could cut a canal from ocean to ocean, and so we might continue from one empire builder to another. But let us not longer delay the telling of the story itself. It is hoped that those who read this narrative will find it packed with genuine interest and useful information. Then, the writing of it will have been much worth while.

FLOYD L. DARROW

Brooklyn, N. Y.

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Builders of Empire

BUILDERS *of* EMPIRE

CHAPTER I

BUILDERS OF EMPIRE

HOW MANY of the boys and girls of this broad land think of free America as an empire? We have no imperial ruler, no sovereign family of hereditary birth and blood, no titled aristocracy — none of those things which usually go with empire. And yet America is an empire. For here we have vast natural resources, boundless wealth, unequaled opportunities and a free people in whose veins flows the blood of many nationalities. These make an empire, though different, it is true, from any in the Old World.

And we have had empire builders, scores of them. Every boy and girl is familiar with many of them. From the day Columbus first set foot upon our shores almost to the present moment, explorers and pioneers have been subduing the wilderness, bringing our broad areas of agricultural lands under cultivation, locating rich mines of valuable ore, establishing industries and building homes and cities. That is empire-building, and the story of it is

a fascinating one. In this work, great leaders have arisen — men and women who have built their very lives into this vast structure which we call American civilization. It is about some of these leaders and their achievements that I wish to tell you now. I should like to go back to the very beginnings of empire-building upon this continent, but I fear you would grow weary of so long a story. We must content ourselves with the narration of the more recent triumphs. Great conquests have been made since our Civil War. Your grandparents and your fathers and mothers can tell you of many of these happenings. Romance aplenty crowds every page of this half century, and more, of wonderful progress. In that romance, I think every one of you is interested.

Let us begin with the story of agriculture. This is the most important industry in any country. Without it, we can readily see that people would starve. And now I want you to go with me to a harvest field near Lexington, Virginia. It is the year 1832. "That is long before the Civil War," I hear some of you saying. Yes, I know it is, but the young man whom we shall see there and the victory which he scored were bigger factors in building the agricultural empire stretching from the Alleghenies to the Rockies than probably any other influence. This youthful inventor, too, lived for nearly a generation after the close of the Civil War, and his invention is as important still as it was on that harvest day nearly a century ago.

Before us we see a field of ripened wheat and a crowd of curious onlookers. Country gentlemen, lawyers and politicians, farmers and laborers, shouting negroes and

idle gossipers have gathered for some unusual event. A feeling of tense excitement seems to pervade the atmosphere.

Presently, a tremendous roar greets our ears, and we look beyond the throng of spectators to the field of grain. Ridicule, uproarious laughter, jeers and hoots mingle with a general clatter of noise from a most outlandish looking machine. One man shouts, "It's drunk." Another defiantly asserts, "We'll smash the things, before we'll have the bread taken out of our mouths by any such contrivance."

What does it all mean? Why this feeling of hostility? As you have already guessed, the machine is the first reaper, and the young man on the driver's seat is Cyrus H. McCormick, twenty-three years old, having been born in the same year with Abraham Lincoln. Grain has always before been cut by hand, and many of those witnessing the historic event are fearful lest this new contrivance deprive them of labor. They cannot see that by bringing many more acres under cultivation it will make more work for all and a greater abundance of food at cheaper prices.

But let us return to the field. Young McCormick is not having an easy time. Far from perfect, the machine does not work well. On the rough field, the reaper slews about like a storm-tossed ship on an angry sea. The jeers of the crowd increase. The owner of the field, in real or fancied alarm, rushes up and shouts, "Here, here, young man! Stop your horses. You're ruining my wheat."

Humiliation and failure seem the lot of McCormick. He has spent many months on the machine, and his father

had spent fifteen years before he began. "Is it all to be for nothing?" we can almost hear him say. But just at that critical moment a friend appears. The Hon. William Taylor, who owns the adjoining farm, rides up on horseback and says, "I'll see that you have a fair chance, young man. Pull down that fence over there and see what you can do in my field."

The ground is not so rough. The machine works better. Round and round the field McCormick goes, the rattle of the machinery making sweet music in his ears. The crowd grows silent. Something extraordinary is happening. In five hours six acres of grain have been laid low. Nothing like it has ever been known before. He stops the machine, and the people crowd about, many with praise. Most gratifying of all is the voice of his father saying, "Your reaper is a success, and it makes me proud to have a son do what I could not do." The principal of the village academy announces, "That machine is worth a hundred thousand dollars."

But dark days and many years of disappointment were ahead of McCormick. His first obstacle was the discovery that the reaper would not cut wet grain. Baffled for a time, he nicked the edge of his cutting blade like a saw, and the difficulty was overcome. Business reverses made him a bankrupt and eight years passed before he sold a single machine. Then, one day in 1840, a farmer from some distance rode up to the inventor's door and offered fifty dollars for a reaper. Gladly, the offer was accepted, but McCormick immediately set his price at one hundred dollars and within the next four years built and sold eighty-six more.

An early McCormick reaper

Courtesy of the Canadian National Railways

As they reap wheat today. A scene in the harvest fields of Saskatchewan

It was not long before orders began to come from the country beyond the mountains. Transportation was slow and costly in those days, for railroads had hardly begun. Sometimes McCormick's reapers did not reach their destinations until too late for the harvest. One day a friend said to him, "Why don't you go West where there's lots of room and where you can get land for your factory cheap?"

The idea took root and not long after, with three hundred dollars in his pocket, McCormick took a journey into the far-country. It was harvest time and much grain was going to waste because there were too few hands to cut it. It did not take a prophet to foretell that without his reaper those fertile plains of the Middle West could not be developed. Selecting the frontier town of Chicago, McCormick moved his plant there in 1847 and also formed a partnership with the mayor of the city, William Ogden, who supplied him with twenty-five thousand dollars to build a factory.

In the next two years, the new firm built and sold two thousand reapers for use on the surrounding farms. Business thrived. This was just the invention needed for those rich farming areas. Machines could not be turned out rapidly enough. But the two partners could not agree, and in 1849 McCormick bought Ogden out for fifty thousand dollars.

Still, those first reapers were very imperfect machines. One man was required to walk beside the reaper and rake off the grain into bundles, and there was no self-binder. But soon improvements began to come. Jearum Atkins with a revolving-arm attachment displaced the man beside

the reaper. The Marsh brothers of DeKalb, Illinois, added a platform and table, where two men stood and bound the bundles as they came from the revolving-arm. In 1874, Charles Withington invented a self-binder using bands of wire. A little later, John Appleby substituted twine for wire, and the reaper essentially as we know it today became the permanent possession of the American farmer.

McCormick bought these inventions as they came and made improvements of his own. In 1851, he exhibited his machine at the Crystal Palace Exhibition in London. At Paris, in 1855, he was awarded a gold medal and succeeded in selling a reaper to Emperor Napoleon III. Soon McCormick reapers were in use in Great Britain and on the Continent. In 1871, the great Chicago fire swept away his plant, but he built a bigger and better one and was soon producing fifteen thousand reapers a year.

When McCormick died in 1884, an agricultural empire of vast extent stretched away for hundreds of miles in almost every direction from the great city at the foot of Lake Michigan. In the building of both, he had had a large part. I am sure you will agree that the boy inventor of Virginia is entitled to a foremost place among the empire builders of the nation.

From Prairie to Packing House

In the very year in which McCormick was making his memorable demonstration with the reaper, there was born on a farm in Oneida County, New York, a boy, Philip Danforth Armour, who was to become a pioneer in con-

verting the live stock on the prairies of the Great West into finished meat products for eastern markets.

We see him first, as a boy of nineteen, making his way overland with those groups of hardy pioneers who, in '49 and the years following, descended into the gold fields of California. His imagination had been fired by the stories of easy wealth floating eastward from that bright Eldorado of sunshine and gold. But he did not run away. He told his mother of his purpose, and she, realizing that he was determined to go, gave him three hundred dollars with which to make the journey. With a number of equally enthusiastic companions, he set forth, and after six months of severe hardship found himself in the land of his dreams.

Still, young Armour did not begin to make his fortune by digging gold. He decided that it would be more profitable to dig sluices to aid other miners in extracting gold from the sands. For this he received five dollars a day, and he soon became a contractor. In five years, he had saved four thousand dollars. With this he returned home.

On his way back, Phil, as he soon came to be known to everyone, had stopped in Milwaukee. At that time, this city by the lakeshore was more important than Chicago. It was really the gateway to the West. There, he decided, was the place to invest his capital in some business, for the blood of the trader was in his veins. Years after, he said, "I had been studying the methods then used for moving the vast and growing food products of the West, such as grain and cattle, and I believed that I could improve them and make money."

And so Phil Armour, just before the Civil War, es-

tablished himself as a grain and produce merchant of Milwaukee. Prosperity came in abundance, and the name of Armour soon became known far and wide in business circles. Following the war, Chicago began to forge ahead of Milwaukee. It was the natural center for the metropolis of this rapidly growing empire of agricultural wealth. There, Armour transferred his activities and, in 1867, became a pioneer founder of the great meat-packing industry.

The packing of meat was as essential to the growth of agriculture in the Great West as the reaper or the railroad. With the invention of the refrigerator car, it was no longer necessary to ship live stock from the western plains to eastern markets. Armour built his own line of cars and began the business of preparing dressed meats in prodigious quantities for distribution at all seasons of the year in every part of the country, particularly in the East.

In the early days of meat-packing, there was great waste. But Armour soon changed the picture. He once said, "Give me the waste from the animals slaughtered and I'll make more money than the fellow selling the meat." He converted this waste into glue, fertilizer, soap, candles, buttons, oleomargarine and much more. We call these by-products. Without them, the industry would perish. It is said that only the squeal of the pig escapes being put to use.

Armour was a man of boundless energy. Once, when he had bought an immense quantity of wheat, he found himself with no place to put it. His competitors had closed every grain elevator against him. Ruin stared him in the face. Although it was the World Fair year and

labor was scarce, he began to build his own elevator. He was told it would take six months. He had it ready in forty-two days.

As the years passed, this pioneer of industry amassed a large fortune. One Sunday, he heard the great pulpit orator, Dr. F. W. Gunsaulus, preach a sermon on the subject, "What I would do with a million dollars." Dr. Gunsaulus unfolded his vision of a great technical school for boys. When the sermon was over, Mr. Armour went forward and said to Dr. Gunsaulus, "If you will give me five years of your time, I will give you the money." The offer was accepted, and today we have the Armour Institute of Technology. In many other ways this man gave of his time and his wealth.

When asked once if the chance of the average American boy for success is as great now as when he began life, he said, "Every bit and better. The affairs of life are larger. There are greater things to do. There was never before such a demand for able men."

Today his picture hangs in the Hall of Fame of the University of Illinois.

In 1875, there appeared in Chicago a young man who was to write his name in big letters in the packing industry of the land. Even as a lad at West Sandwich, Massachusetts, Gustavus F. Swift had invested his first savings in a calf, which he raised for market. Outgrowing the butcher business which he established in his New England home, Swift moved first to Albany, New York, and then to Chicago. The advice of Horace Greeley, "Young man, go West," had captured his imagination. Starting with

small capital, the business grew to vast proportions, and, when the head of the firm died in 1903, the name of Swift was known from ocean to ocean and in foreign lands. His sons now conduct the business.

A Molder of Living Things

SOMETHING more than a half century ago, a New England lad found a seed-ball on one of the plants in his mother's potato patch. Tremendously interested, even as a child, in all living things and particularly plants, he picked it. Presently, he lost it, but found it again. Hardly knowing how to do so, he planted the seed. From this adventure came the famous Burbank potato. The youthful experimenter sold his discovery for $175, but the United States Department of Agriculture estimates that this potato adds $17,500,000 yearly to the farm incomes of America.

Born in Lancaster, Massachusetts, in 1849, Luther Burbank, at the age of twenty-two, traveled westward to California. There, in that land "where every day is a suggestion of May, and winter never lingers," he believed that he would find the opportunity to develop his intense love for agriculture. He took with him a satchel full of his precious potatoes and a little money. His money was soon gone. He spent the last of it for a hatchet to use on a promised shingling job which did not come. At last he found work on a chicken farm and saved every penny he did not need. Soon, he was able to buy a small plot of ground, and there, in the early 'seventies of the last century, he established the nursery which grew into the world-renowned Luther Burbank Experiment Farm and

became the home of the Luther Burbank Society. There, this lover of Nature did those wonderful things with plants which led Dean Brink, of the Kansas State Agricultural College, to say that Burbank's "contributions to human comfort are greater than all the gold taken from California."

Burbank became a breeder of plants. That is, he studied the laws of plant growth and learned how to produce new varieties of plants. Even as a boy in Massachusetts, he produced sweet corn which ripened two weeks in advance of that of any of his neighbors. One of the first things he did in his little nursery in California was to fill a hurry-up order for twenty thousand prune seedlings to be ready in nine months. One of the world's largest prune orchards grew from those young trees. In his working life of nearly a half century, Burbank made more than one hundred thousand separate experiments in growing plants. From them grew over a billion individual plants.

And what are some of the things this man did? In place of the spiny cactus, he gave us the Spineless Cactus and made it produce a fruit which is excellent for canning and delicious to eat raw; he grew a white blackberry and a stoneless plum; he changed a troublesome weed into the beautiful Shasta Daisy; he doubled the quantity of fruit obtained from the cherry tree; he showed how to hasten the growth of the walnut tree; he perfected a strawberry which bears the year round; he developed a sort of freak plant which bears potatoes underground and tomatoes above; he changed the poppy's color and made a chrysanthemum-like daisy; he produced the Burbank rose and

learned the secrets of flower growth; he taught new habits to old plants; he discovered a quick way of growing trees for lumber; he taught us methods of grafting and budding; and he did much more. It would require volumes to tell the whole story.

In the field of living things, Burbank has accomplished wonders as great as those of Edison with electricity, Bell with the telephone, Westinghouse with the air-brake, Carnegie with steel, and the Wrights in the air. And the work of this molder of life, like that of other creators, will live for centuries to come. In the written records of his work, Burbank has left a legacy of priceless value as the heritage of all succeeding generations.

The boy who loved plants placed his ear close to Nature's heart, and to him she revealed her secrets.

Trails of Steel

WHAT would a modern empire be without great highways of transportation? As vital to industry as ignition to a gasoline motor are roads, canals, railways and steamship lines. Chicago became the agricultural outlet and business metropolis of the Great West because of the railroads which centered there. It was the early canals and railroads of Pennsylvania which made possible the development of the rich mines of coal and iron in the Keystone State. The building of the Erie Canal a century ago made Central New York the natural highway to the Lakes and the West and raised New York from fifth to first place among the states of the Union. No section of a country can thrive without means of transportation.

The coming of railroads has converted a wilderness into an empire.

We are all keen for the thrill of adventure and the story of great achievements. And that is what we find strewn all along the highway stretching from the days of the ox-cart and the "Covered Wagon" to the Twentieth Century Limited and the airplane. A picturesque era of human happenings this highway spans, and in it we find great leaders and the monuments which they built. Let us become better acquainted with a few of them.

We shall begin with Cornelius Vanderbilt, better known as "Commodore." This builder of transportation systems belongs to several periods of our country's history. He was born in 1794, on Staten Island, New York, in sight of where I am now writing. This was while Washington was still president, and he did not die until 1877, so recently that your grandfather can remember when he was still living. His adventures in railroading did not begin until about the close of the Civil War.

Vanderbilt was descended from an old Dutch family which settled in Brooklyn, New York, in 1650. His father was a farmer and to get his produce to market it was necessary to transport it by boat across the harbor to New York City. While he was yet a lad, Cornelius engaged in this work of carrying farm produce to market. He employed a sail boat for this purpose, and often he was the captain and the whole crew. At the age of sixteen, he became the owner of a schooner and carried both freight and passengers. It was a profitable business, and two years later he found himself the commodore of a fleet of three such boats. Gradually he extended his traffic to the

Jersey coast, Long Island Sound and the Hudson River towns. He became an operator of ferry boats and an owner of ships which ventured upon the high seas. When steam came, he built steamships and in the years of the gold rush carried miners and freight to Nicaragua on the route to California. And with it all came wealth.

About the beginning of the Civil War, American shipping was swept from the seas. It was no longer able to compete with ships built and manned abroad. At this time, the Government needed ships in its struggle with the South. Vanderbilt made a gift of one of his best ships and sold others. At this time, he found himself out of the shipping industry, but although nearly seventy years old he could not give up the business of transportation. Little did he know that his most lasting work was still ahead.

Now many times a millionaire, Vanderbilt bought railroad properties which he consolidated into the New York Central Railroad system, reaching from New York to Chicago. His interests extended into the West and Northwest and even across the continent to the Pacific. Everywhere he improved his lines, gave better service, built branches and was a large factor in developing the commerce and industry of the country.

From his youthful years to old age, Vanderbilt was continually engaged in bitter warfare with competitors. One of his most notable struggles was with Jay Gould for the control of the Erie Railroad, a contest which he lost. Rugged, gruff, shrewd, with a passionate love for big undertakings, Cornelius Vanderbilt will be remembered as one of the leaders in the era of modern railroading in

America. His most important gift was a million dollars for the founding of Vanderbilt University at Nashville, Tennessee.

Spanning the Rockies

By the time the Civil War opened, railroads had spread like a network over the states of the East and the Mississippi Valley. They had crossed the plains and reached the foothills of the Rockies, but there they stopped. How to carry the trails of steel over this mighty barrier, thrust skyward many thousands of feet and extending westward for hundreds of miles, seemed a baffling problem. But people lived on the other side of those mountains, people forming a part of our own country. There were in that distant land, too, valuable products of forest, mine and farm which were needed in the East. A better and quicker route than those by way of Cape Horn or the Isthmus of Panama was needed. Without direct transportation facilities, the Pacific coast could never become a working part of the nation. A railroad over the mountains was demanded by the people, both East and West. It simply had to be built.

Railroads are built by men. Interwoven with their construction are great personalities. In each there is always some directing mind, often several. And so it was with the building of this first transcontinental line. Probably the most important of these pioneers of transportation was Leland Stanford of California.

We see him first as a vigorous youth on a farm near Albany, New York, where he was born in 1824. Those

early years were filled with hard work and stern discipline. The boy who was later to acquire millions and to give his name and a part of his fortune to a great university had little money. One autumn he and his brothers made $25 by gathering chestnuts and selling them in Albany. During the winter months he attended the village academy, but the study of law, which he wished to take up, seemed out of the question. Then fortune turned his way. When young Stanford was eighteen, his father bought a piece of woodland which he wished to have cleared for cultivation. He told his son that he might have the cordwood which he could cut from the land if he would clear it up ready for the plow. He hired men to help him and the profit from the undertaking netted $2,600. With this, he entered a law office in Albany and in 1849 was admitted to the bar.

Like many another young man of those stirring times, the West lured him. But he did not go at once to the gold fields of California. He first opened an office at Port Washington on Lake Michigan, not far from Milwaukee. He had not been there long when his house and law library were lost by fire. After returning East to be married, he set out for the land of gold. Several of his brothers had already gone. In this new country, Stanford abandoned the law and became a merchant. The big-hearted, burly young man made friends rapidly. His business thrived. He entered politics and before ten years had passed had become a leading citizen of the new state.

The agitation for a railroad to be pushed over the Rockies to meet the Union Pacific, which was coming from the East, became the chief topic of the day. In this

movement, Stanford took a leading part. Returning from Chicago, in 1860, where he had been a delegate to the National Republican Convention which nominated Abraham Lincoln, he set about organizing the Central Pacific Railroad Company. In the following year, this was accomplished, and Stanford was chosen president. Among his associates were Collis P. Huntington, Mark Hopkins and Charles B. Crocker, all destined to become important figures in the railroad systems of the West.

Both the State of California and the Government at Washington gave assistance with money and grants of land. Vigorously, the work went forward, but government aid was slow in coming, and the task of keeping the huge project moving was a tremendous one. Largely, it fell upon Stanford. It was in 1863 that, with his own hands, he turned the first spadeful of earth. Then the troubles began. Huntington says, "There were difficulties from end to end: from high and steep mountains; from snows; from deserts where there was a scarcity of water, and from gorges and flats where there was an excess; difficulties from cold and heat; from a scarcity of timber and from obstructions of rock; difficulties in keeping a large force on a long line; from Indians; and from want of labor."

One of the chief difficulties encountered was from hostile Indians. Raids were of almost daily occurence and hundreds of lives were lost. So serious did the situation become that at one time the Union Pacific division was about to abandon the construction. But just then Major Frank J. North, an experienced Indian fighter, appeared and saved the day. In those pioneer days, the buffalo still

roamed the plains and afforded abundant supplies of meat for the workmen. Building supplies for the western division had to be brought by boat around Cape Horn and then carried inland by wagon. It was a herculean task, but the work never faltered.

The engineer to whose genius we must credit the threading of mountain passes and the overcoming of natural barriers was Theodore D. Judah. So great a discoverer of highways through the mountains did he become that he was given the title of "The Railway Pathfinder." But he was much more than that. He was the general who solved the problems of construction and led the forces forward through the mountains.

At length, after six years of terrific effort, the two roads, that from the East and that from the West, met. At Promontory Point, in Utah, on May 10, 1869, Leland Stanford and Thomas Durant, the presidents of the two roads, drove golden spikes into a tie of polished laurel. The East and the West were at last joined with ribbons of steel. Other roads followed, and the "Overland Route" with its caravans of "Covered Wagons" gradually faded from the picture and became but a picturesque symbol of former days.

Stanford was elected Governor of California and later United States Senator. At his great ranch at Palo Alto, he became a student of agriculture and a breeder of horses. In memory of their lost son, Leland Stanford, Jr., Mr. and Mrs. Stanford founded at Palo Alto the great university which bears their name. A member of its first graduating class was Herbert Hoover. In 1893, Stanford died, but his name and what he did live on.

The Empire Building of the Northwest

Now let us go far to the North. It is the year 1870 and we find ourselves in a dense wilderness of Canada near Fort Garry, now the city of Winnipeg. A terrific blizzard fills the air with blinding snow. It is impossible to see even a yard ahead, and the stinging particles of ice prick like needles. A young man staggers forward in the approaching darkness of early night. His dogs have lost the trail and are going in a circle. Presently, he abandons his sled and food in a drift. Death seems but a matter of a few short hours, or possibly minutes. Suddenly, a light gleams and the dim outline of a log cabin pierces the driving snow. He tries to call out, but his voice fails him, and with his last ounce of strength he throws himself against the cabin door and falls senseless. When he awakes, he is in a warm bed and a trapper and his wife are bending over him. James J. Hill, the empire builder of the great Northwest, but then the head of a small trading company, has had his closest call to death.

Fourteen years before, when an eighteen-year-old boy, Hill had found himself in the settlement of St. Paul on the upper Mississippi, practically alone in the world and without money. He had made his way from his birthplace in Ontario, Canada, to this outpost of civilization and gateway to vast areas of unknown country for the purpose of joining the Red River Brigade of the great Hudson Bay Company. But when he arrived, the trading brigade had gone, and so he found a job as shipping clerk with a steamboat company at seventy-five cents a day. He saved his money and in less than ten years formed a

trading company of his own. It was on one of his frequent trips into the wilderness of Canada to buy furs that we saw him lost in the blizzard.

Not satisfied with the prosperous business of a trader, Hill was constantly on the lookout for bigger opportunities. He dreamed of a day when a great flourishing empire of agriculture and industry should replace the unsettled plains and forests of the great Northwest. In that little-known country were vast natural resources which he longed to develop. At length the day of opportunity arrived. In 1873 the St. Paul and Pacific Railway went into bankruptcy. The road had a debt of $33,000,000 and was only 500 miles long, but in it Hill saw the possibility of making his dream of empire come true. Pledging his own small fortune, which had now grown to $75,000, and obtaining the financial assistance of friends, he gained control of the road, described as "two streaks of rust reaching into a desert." There were no farms then in that wide expanse of fertile plains, stretching away for hundreds of miles to the table-lands at the foot of the Rockies. But soon the thrill of life began to be felt in the Red River Valley, and fields of waving grain replaced the barren wastes.

The road prospered and with it the whole Northwest. The "Twin Cities," St. Paul and Minneapolis, became the outlet for one of the richest agricultural regions of the world and grew with the country. Hill extended the road, organizing the Great Northern, which in 1893, in the face of the most disastrous business panic in half a century, he carried across the mountains to Puget Sound. This was the first transcontinental railroad to be built

Courtesy of the General Electric Company

The *Oriental Limited* of the Great Northern Railroad, with electric locomotive, en route through the Cascades

A pioneer locomotive

without a dollar of government money or a foot of government land. It was a great achievement and stamped Hill as the foremost railroad builder in America. Gradually, he added other lines and his system became one of the most important in the country. Without it, the Northwest would remain today, what Hill found it, an unknown land of vast undeveloped resources.

Hill once said, when asked for the secret of his success, "Whatever I have accomplished has been due to taking advantage of opportunities, and I have not been watching the clock. The simple truth is that any man who attends to work will succeed anywhere." One of his employees said, "He expects everything to have been done yesterday." When he talked, the whole world listened. As a boy, he took Napoleon as a guide, and Thomas Carlyle was a favorite author. He was a breeder of cattle and horses and taught the people of his country the science of agriculture. In James J. Hill, a citizen by adoption, America found one of its greatest leaders.

A Pioneer of Colorado

Other railroads across the Great Divide followed. The Denver and Rio Grande carried its lines to Pueblo, 120 miles south of Denver, and thence westward through the famous Royal Gorge to Salt Lake City. The Union Pacific crossed the mountains to the north. But no road led directly westward from Denver. An immense territory rich in petroleum, coal, timber, mineral wealth and fertile soils had no railroad outlet. Then, in 1902, David H. Moffat, pioneer of industrial development in

Colorado, determined to build a road over the mountains to Salt Lake City. Few men at the age of sixty-three would have undertaken such a prodigious task. Until his death in 1911, he never faltered. Single handed, he carried the road to Yarmony, 130 miles from Denver. Then, following along the trail blazed by Moffat, others built the line to Craig, beyond the mountains. At Corona, the road crosses the Continental Divide at an altitude of 11,660 feet. Within a two hours' run from Denver, a train climbs upward 6,000 feet.

The road is never free from snow, and in winter operation is often suspended for weeks at a time. Nearly half of the operating expenses are due to this white elephant. Even when the track is free from snow, it requires four of the most powerful locomotives to haul a train of twenty-two cars over the divide.

Still, there was a way to avoid this snow peril and to reduce largely the heavy grades. A tunnel under James Peak would accomplish this and at the same time shorten the distance over the mountains by 23 miles. For many years Eastern bankers refused to loan the money for the undertaking. Finally, in 1923, with state aid the tunnel was begun. Early in 1928 the task was complete. A hole 6.09 miles long had been bored through solid granite, the second longest tunnel on this side of the Atlantic. By cutting off the circuitous route to Pueblo and through the Royal Gorge, it lessens the distance from Denver to Salt Lake City by 173 miles. More important, it taps one of the richest portions of our country. Everywhere known as the Moffat road and tunnel, this vast undertaking will forever remain a monument to the breadth

of vision and patriotic service of the man who dedicated to its accomplishment his fortune, his heart and his declining years.

"The Colossus of Roads"

An errand boy in Wall Street at fourteen, a partner at eighteen, owner of a brokerage business and a seat on the New York Stock Exchange at twenty-two and a multi-millionaire before thirty, Edward H. Harriman has been called "the Colossus of Roads." When he died in 1909, he owned and controlled more lines of railroad than any other man in America. It is said of him that he "wrote his name in iron and steel across the face of the continent."

Harriman was born on Long Island in 1848, the son of an Episcopal minister and one of six children. When his family moved to New Jersey, he and his brothers attended Trinity School in New York, walking two miles to the ferry and another mile after landing in Manhattan.

At forty-five, he became a director of the Illinois Central Railroad and later its vice-president. He immediately set about mastering the business of railroading. He wished to be ready for bigger things. In the panic of 1893, his opportunity came. The Union Pacific, the first transcontinental line, went into bankruptcy. Harriman formed a company to reorganize it. In a private car, with the car placed ahead of the locomotive, he went over the whole line, traveling only in the day-time. In his wonderful memory, he stored up a detailed picture of the needs of the road. He also saw the vast possibilities of the immensely rich farming and mining country traversed

by the road. Into its rebuilding, he poured his own millions and others which he borrowed. The road prospered, paid its debts and once more became one of the most profitable railroad lines in America. And he built branches and brought other roads under his control.

Probably his greatest source of pleasure was, not in his millions or his railroads, but in the East Side Boys' Club in New York, for which he built a club house and where he delighted to mingle with boys and be one of them.

In this land of immeasurable wealth, and big with opportunity, empire builders have come and gone, and others have taken their places. It always will be so. This country of ours is still youthful. Its biggest achievements are ahead of us — in the great tomorrow.

Uncrowned Kings of Steel

No EMPIRE of this modern world can grow big and prosperous without prodigious quantities of steel. Back of the builders of agriculture and railroads stand the mines of coal and iron. How could McCormick have made a reaper had not steel been ready for his forge? And railroads too — from spikes and rails of the roadbed to cars and locomotives, they are practically all steel. Elevators of steel hold the ripened grain. Steel ships carry it to market. Plows and harrows of steel fitted the fertile soil in which it grew. Even Armour and Swift housed their industries in buildings of steel and transported their products to market in cars of steel. Forests are felled with axes and saws of steel and the logs are transformed into

finished lumber with machinery of steel. In countless scores of ways steel ministers to our needs. Every boy and girl who reads this book can count dozens of ways in which steel is necessary to his or her happiness. Your knife, your skates, your tools, the delicate hairspring of your watch, the parts of the family car, the furnace that heats your home and hundreds of other articles are fashioned from steel. Just try taking away all the things of which you can think which are made of steel, and then picture the world in which you would find yourself. This is sometimes called the Age of Steel, and so it is. Machines of steel provide every man, woman and child in this country with the equivalent of fifty hard-working slaves.

One day, some years ago, I found myself beside the fiery furnace of an immense steel plant. Into a huge, egg-shaped crucible turned into a slanting position to receive it, I saw a mighty crane pour from a "ladle" fifteen tons of white-hot, molten pig iron. Immediately, a powerful engine placed the crucible in a nearly vertical position, and a deafening roar greeted my ears. A sheet of flame shot from the crucible's mouth, a shower of sparks pattered about like hail and the roar continued. Fifteen minutes passed. Then, lo, the flame almost disappeared, the sparks vanished and quiet reigned. Quickly, the crucible was turned back into its slanting position, and workmen added a few hundredweight of a metallic looking substance. Once more the "blow" filled the air with its ear-splitting vibrations, but only for five minutes. Then, behold, I saw this seething caldron turn on its trunnions and pour into a trainload of waiting molds

liquid metal, and all as easily as water is poured from a pitcher into a row of tumblers.

I had witnessed the Bessemer process of converting pig iron into steel. With this invention, Sir Henry Bessemer in 1856 had bridged the gap from the Age of Iron to the Age of Steel. A dozen years later, Andrew Carnegie, a young Scotsman from Pittsburgh, visiting England, had witnessed the same marvelous transformation. Fascinated, he hurried back to America to introduce the invention there. True, William Kelly of Eddyville, Kentucky, had made the same sort of furnace at about the same time, but Carnegie did not know it, and it did not matter. The prophetic vision of this keen Scotsman told him that here were the metal and the process necessary to convert the vast natural resources of America into an industrial empire of colossal proportions. As fast as a steamship could carry him, he returned to the land of his adoption.

But before this supreme moment arrived, thirty-seven years of Carnegie's life had passed, years of which we wish to know something. He was born at Dunfermline, Scotland, in 1835 and, at the age of twelve, migrated with his parents to Allegheny, Pa., opposite Pittsburgh. There, he became a bobbin boy in a cotton mill at $1.20 a week.

But Andy, as he was soon known to all his friends, did not long remain a bobbin boy. He found a better job as a telegraph messenger in Pittsburgh at $3 a week. In his spare moments, he learned to send and receive. One morning, before the regular operators had arrived, he received a message and delivered it. For this, instead of

being fired as he had feared, young Carnegie was soon made an operator himself at $25 a month. He attracted the attention of Thomas A. Scott, Pittsburgh superintendent of the Pennsylvania Railroad, and he made him his secretary at $50 a month. Once in the absence of the superintendent, when the road was tied up by an accident, he sent orders signed "Thomas A. Scott" and cleared the wreckage for traffic.

One day, Scott asked Carnegie if he could find $500 to invest. He immediately answered, "Yes, sir, I think I can." He did not then know how it would be done, but he consulted his mother, and she mortgaged the home to raise the money. With it, he bought ten shares of Adams Express Company stock. He was now a capitalist. A month later, he received a dividend check. His second venture was an investment in a sleeping car patent. He borrowed the money at the bank, for he had a good reputation. That stock made him $10,000 and also gave him a foothold in the Pullman Company.

During the Civil War, Scott was made vice-president of the railroad, and Carnegie succeeded him as superintendent. When Scott became Assistant Secretary of War, he was placed in charge of military railroads and telegraphs.

Being a railroad man, he asked himself one day, "Why not build iron bridges?" He immediately organized the Keystone Bridge Company with J. Edgar Thomson, president of the Pennsylvania Railroad, at the head and Colonel Scott as vice-president. Within four years, the company was paying 100 per cent dividends. He now became an owner of oil wells and a member of other

enterprises. At thirty-two, he had built a fortune of $100,000. It was at this time that he visited England. While abroad, he sold several million dollars worth of bonds for an American organization and cleared $225,000 in commissions for himself. He returned to America with the romance of steel firing his imagination and sufficient capital to bring his dreams to pass.

Immediately, Carnegie organized a company with a capital of nearly three-quarters of a million dollars and built the Edgar Thomson Steel Works. In fifteen years, his fortune had grown to as many millions. Everywhere he was recognized as the master leader of the steel industry. He surrounded himself with the most brilliant men he could find and moved forward to still greater conquests. In addition to steel mills, he became the owner of mines of coal and ore, coke ovens, steamship lines on the Great Lakes and railroads. When the United States Steel Corporation was organized in 1901, Carnegie found himself in control of the situation, and the bobbin boy of the cotton mills sold out his vast interests for nearly a half billion dollars. He had become one of the two or three richest men in the world.

The business of his later years became the giving away of his vast fortune. He gave $60,000,000 to found libraries and vast sums to churches, colleges, hero funds, institutions to promote peace, pensions for workers and college professors and much more. No one before had ever given in such princely fashion. Before he died, Carnegie had in this way disposed of the bulk of his wealth. He preached the gospel that it is discreditable to die rich.

Truly an empire builder, Andrew Carnegie will long

be remembered as the first of the mighty steel kings and the world's greatest philanthropist.

Only one man in the world ever tore up a contract for a salary of a million dollars a year. That person was Charles M. Schwab, the young man whom Carnegie declared "knows more about steel than any other man in the world." From a stake driver at a dollar a day, he rose in six years to be superintendent of the largest steel plant in America and later to the position of chief assistant to the steel king with a salary of a million dollars. When the United States Steel Corporation was organized, in order not to embarrass the new company, this prince of the steel industry deliberately tore up his contract. How did this man, while still young, rise to such a commanding position? Let us see.

At Loretto, Pa., on a crest of the Allegheny Mountains, Charlie Schwab was born in 1862. He was fortunate enough to secure two years of college training, but on leaving school became first a coach driver for his father and then grocery clerk. One of his customers was Captain Bill Jones, superintendent of the Edgar Thomson Steel Works. Everybody liked the good-natured youth, and he made friends rapidly. One day he asked Jones for a place in the mill. Jones asked, "Can you drive stakes?" and Schwab answered, "I can drive anything." The next morning he began work at a dollar a day.

But Schwab was a different kind of stake driver from most others. In his evenings, he studied chemistry and applied his knowledge to improving the quality of steel. This was something new. Few had ever thought that

science had anything to do with making steel. Everything had been done by "rule-of-thumb." Schwab made dozens of experiments to test the strength and qualities of steel under different conditions. Like everyone else, Carnegie "took to" the self-made chemist of steel and recognized his ability. Soon he made him head of the engineering department of the whole Carnegie organization.

Schwab's next step was to show how to build a steel plant which should receive raw material at one end and turn out finished products in a continual stream at the other. Carnegie set him to building the Homestead Steel Works with a salary of $50,000 a year and an interest in the business amounting to as much more. When the plant was complete, Schwab was made its superintendent with 6,000 or 7,000 men under his supervision. And he was then under thirty.

At the end of the great Homestead strike in 1892, Schwab accomplished miracles in winning back the cordial good-will and enthusiastic co-operation of the men. No one could resist his smile and radiant optimism. His reward was promotion to the presidency of the Carnegie Company. From stake driver at a dollar a day, Schwab had risen in fifteen years to the foremost position in the world of steel. A British steel master tried to lure him to England with the offer of a fabulous sum, but Schwab refused. When Carnegie learned of the loyalty of his chief assistant, but not through Schwab, he raised his salary to a million dollars. In the last year of the Carnegie organization, it became $1,300,000.

Schwab remained with the United States Steel Corporation three years, but, lacking the freedom in the carrying

out of his ideas which he had enjoyed with Carnegie, he resigned. He spent some time in regaining his health and then bought the Bethlehem Steel Works, at Bethlehem, Pa., and built it into the second largest in the world. He once said, "Why do I work? What do I work for? I have more money than I can begin to spend. I have no children, nobody to leave it to. My wife is rich enough in her own right. She does not need it. I work just for the pleasure I find in work, the satisfaction there is in developing, in creating things."

During the war, Schwab took charge of the building of ships for the Government, without pay. Here again his enthusiasm was contagious. In shirt sleeves and overalls, he mingled with the men and inspired them to heroic efforts. Once at Hog Island, he addressed two thousand foremen and called upon them to raise the riveting record from fifty-four thousand to two hundred thousand a day. They answered, "Come a month from now, Charlie, and we'll show you." And they did.

Schwab has given lavishly of his money for charity and public works. His record is a pride to his country and an example to the world. Only in this vast empire of American opportunity and equality could such a career be possible.

One day a number of years ago, I got off the train at Gary, Indiana. I had gone there for two purposes. I wanted to visit the schools for which Gary is famous, but most of all I wanted to see the great steel works located in this city made to order.

Armed with a guide and a pass, I soon found myself

beside one of the great ore ships and watched the clam-shell shovel as, dipping into the hold, it removed 17 tons of ore at a single bite. I followed the ore to the huge blast furnaces, each towering 90 feet into the air and turning out 600 tons of molten pig iron every twenty-four hours. I saw this iron in immense open-hearth furnaces converted into steel ingots weighing many tons. And then between giant rolls these ingots, while still white-hot, were shaped into all sorts of steel products.

But what I wish to tell you now is something of the man who gave his name to this city and this plant. We find him first on his father's farm, twenty-five miles west of Chicago, where he was born in 1848. One day he was chopping a tree, which he had just felled, and looked up at the sound of a man's voice saying, "Most of that tree's mine, young feller."

The lad paused, questioning. "Only part of it is on your land," he said. "It was growing on our land and just happened to fall over the line."

"But that part that's over on my land belongs to me," declared the man. And then the boy saw the twinkle in the man's eye.

Still, all the rest of the day, the boy pondered on the merits of the question suddenly thrust before him. "Could the man really claim part of the tree, if he wished?" At night he asked his father. His father could not answer with certainty. The boy concluded that only law books could decide the matter. And that is the way Elbert H. Gary began to think about studying law.

When young Gary had finished public school, he attended Wheaton College and later entered the law de-

The old wasteful method of producing coke for the smelting of iron ore

Side view of a battery of modern coke ovens in which valuable by-products are saved

partment of Chicago University. While studying, he earned money by assisting in the office of the Clerk of the Courts of Cook County. When admitted to the bar, his uncle took him into his Chicago office. The day after the great Chicago fire, Gary opened an office of his own in a wooden building and hung out his shingle. In the first year, his legal fees amounted to $2,800. His ambition was to become a judge, and while still a young man he did so.

His first business venture was an investment in a company for making wire fence, which had come to him for legal assistance. He knew that some day steel would have to replace the fences of wood and stone. In time he became a director of this company. It had then grown into a four-million dollar concern. Gradually, Gary came to be recognized as an able lawyer. His interest in steel grew, and he assisted in forming a number of large steel organizations in the West. Finally, he created the Federal Steel Company with a capital of $200,000,000.

About this time, the United States Steel Corporation was being organized, and J. Pierpont Morgan, the head of the largest banking house in America, asked Gary to take charge of it, serving as Chairman of the Board of Directors. Gary hesitated, but finally accepted and from then (1901) until his death in 1927 he was the head of the greatest industrial organization in the world, in fact an uncrowned king. When he and Mrs. Gary a few years later visited the Orient on a mission of good-will, they were received with all the ceremony usually accorded to royalty.

Probably no other man in America has ever had a better influence in guiding the affairs of big business and labor

than had Judge Gary. The boy who studied law to settle the ownership of a tree became the world's foremost lawyer in the field of industry.

Now I want to tell you a little about another uncrowned king, but not one in the field of steel. Still what he did has a great bearing on steel, for some time our rich mines of iron ore are going to be exhausted. It has even been predicted by one of the world's greatest chemists that iron will be largely gone in a century and a half more. What will men do then? Civilized industry as we know it will be impossible without metals. Primitive men did not progress very rapidly until they had mastered fire and learned how to smelt ores. Metals in abundance, the world simply must have.

First, let me say that undoubtedly chemists will discover ways to use iron ores containing much less metal than is now possible. If this happens, and it undoubtedly will, the time when iron will have become but a memory of the past will be pushed far into the future.

The young man about whom I am to tell you now was Charles Martin Hall. In the middle 'eighties of the last century, he was a classical student, that is, a student of Latin and Greek, in Oberlin College. One day he heard of a new metal, then little more than a curiosity. It was aluminum, so familiar to us now in kettles and saucepans and in many other uses. Still, we have to thank Hall that this metal is not even yet the rare substance which he found it.

Hall had no knowledge of chemistry and electricity, the tools with which he was to accomplish one of the greatest

triumphs in the history of science and industry. Probably if he had he would not have been bold enough to undertake a task which had baffled learned scientists for nearly half a century. His very ignorance was an advantage.

Hall was quick to see that the bright luster, strength and lightness of this metal together with its freedom from ordinary rust would make it ideal for many purposes. Furthermore, it is the most abundant metal in the earth's crust, more abundant than iron. But a great difficulty lay in the way of bringing it into use. The compounds which this metal forms with other elements, that is, its ores, are exceedingly strong. It requires a great deal of energy to extract the metal.

Other men had succeeded in doing this, but the processes were so expensive that aluminum cost $4 a pound. Just think of buying cooking utensils made of so costly a metal!

During the summer of 1886, Hall obtained permission to use the college laboratory for experiments in extracting aluminum from its ore. He had the idea that in some way he could make electricity do this. Still, the summer passed and the weeks and months ran into mid-winter with little result. Finally, he found a way of melting a combination of aluminum ores with electric heat and separating the metal. But it was years before he developed this into a successful process and obtained capital to build a plant. His first important location was at New Kensington, Pennsylvania. Later, when the immense waterpower at Niagara Falls began to be turned into electricity, Hall's factory for producing aluminum was the first to use power from the great cataract. In 1911,

Hall was awarded the Perkin Medal by the American Chemical Society for his discoveries. At that time, he was producing 40,000,000 pounds of aluminum a year and had brought the price to 22 cents a pound.

What the world needs is a process to extract aluminum from cheaper and more plentiful ores than those now used. Aluminum exists in the very clay beneath your feet. When we learn to separate it cheaply from this, aluminum may give its name to a new age of metals.

Other pioneers in the aluminum field were Hamilton Y. Castner of Brooklyn and A. H. Cowles of Cleveland.

I have now told you of a few empire builders of America. There are many more. We shall find some of them in succeeding pages. And do not fancy that empire building has ceased. Just as important things are to be accomplished in the future. I once heard Dr. Willis R. Whitney, Director of the Research Laboratories of the General Electric Company, say that we have hardly yet scratched the surface of science and invention. Did I not just mention this problem of getting aluminum from common clay? Some day, someone will solve it. And there are scores of other problems. Maybe you can help.

Pouring molten steel from an open-hearth furnace

A white-hot steel ingot being hammered into shape under the terrific blows of a steam hammer

CHAPTER II

AN EMPIRE IN OIL AND CARS

NOT LONG ago, I drove by the spot on Oil Creek, near Titusville, Pennsylvania, where Colonel Drake in 1859 sunk the first oil well. But do you suppose Drake had any idea of the vast new empire of wealth and power which that well was to usher in? The car in which I rode was not even a vision in the imagination of the boldest dreamer of that day. And yet, without that well and the flood of oil which has followed it in every part of the country, automobiles would still be in the distant future.

Just think for a moment what that first well and all it symbolizes has meant to the world. Then, petroleum was an untried factor in world affairs. Today, international relations are soaked in this liquid motive power of modern civilization. Do you know that the *Olympic* burns 7,500 tons of crude petroleum in one round-trip across the Atlantic, and the *Majestic* a still larger quantity? What would the world's merchant marine and the navies of all nations do without this liquid fuel? And where would you and I be without gasoline for our cars?

Suppose that gasoline gives out? Despite the present abundance, it is beyond question that American wells will not continue to pour forth such prodigious quantities for

many more years. Long before another century passes, most of them probably will have gone dry. What shall we do then? Well, we need not be too greatly alarmed. Our oil shales, rocks containing oil but not in a state which will flow, of which we have a vast estate, will yield oil for many years after our liquid wells have gone dry. And then, too, scientists have recently shown how to liquefy coal and turn it into oil. There is a bright lining to this hideous nightmare of a gasoline famine, but it is not all silver. Oil and gasoline from these new sources will cost more than they do now. A friend from Australia told me that gasoline sold there at one time for $1.25 a gallon. Just think of driving up to a filling station and putting in ten gallons of gas at that price! Probably gas will never come to that figure here, but in the years to come it will not again be as cheap as it is today.

Don't you suppose Colonel Drake would sit up and rub his eyes in utter bewilderment if he could look at the world today and see the product of his oil well illuminating the remotest quarters of the globe and being transported in every conceivable way from tank-cars and oil ships to elephants, camels, burros, rafts, and Chinese and Indian coolies? In the dark places of the earth — in China, Africa and South America, and in the islands of the sea, backward peoples have been taught how to use petroleum for illumination and heat. With astonishing rapidity following Colonel Drake's discovery, this use spread throughout this and other lands.

Then came gasoline, an unavoidable product of the refining of petroleum and at first a drug on the market. Its greatest use was for cleaning clothes. Refiners reduced

the necessary output to the lowest possible quantity and sometimes used it to adulterate kerosene, little dreaming that in a few short years a new means of motor transport would revolutionize the picture. None of the younger readers of this book can remember a time when there were no cars and when gasoline stations did not line the highways, but we older ones can. The gasoline age is the most recent one in the material progress of the world.

Back of petroleum and automobiles, of course, stand some great personalities. I have no doubt that you want to know more about two or three of them.

Just twenty years before Colonel Drake sank that first oil well, there was born on a farm in Tioga County, New York, a boy who in his early manhood was to establish the business of refining oil as we know it today and to build an organization which has extended its influence into every part of the world. I do not need to tell you that that boy was John D. Rockefeller.

One day this country lad said to another farmer's boy, "I would like to own all the land in this valley, as far as I can see. I sometimes dream of wealth and power. Do you think we shall ever be worth one hundred thousand dollars, you and I? I hope to be — some day." Sometimes our dreams come true. They did so in this case, far beyond the boy's wildest fancy.

Until he was fourteen, Rockefeller lived and worked on the farm. Then, he moved with his father and mother to a small place not far from Cleveland, Ohio. There, he attended high school, but did not graduate, and entered a business college, where he remained for a short time. At

sixteen, he thought it necessary to leave school and find work. He has told how he got his first job. He says, "I tramped the streets for days and weeks, asking merchants and storekeepers if they didn't want a boy. But no one seemed to need a boy, and very few showed any overwhelming anxiety to talk with me on the subject. At last one man on the Cleveland docks told me that I might come back after the noonday meal."

Rockefeller did so, but in his anxiety not to lose the chance he said nothing about the pay he was to receive. Not until three months had passed did he discover what this was to be. His employers then paid him $50. His work was to assist the bookkeeper. He had not been there long when the bookkeeper left, and Rockefeller offered to do the work for $500 a year. The offer was accepted, and he found himself in a position where he could learn much about the ways of doing business.

A trifling incident shows one important characteristic of this boy. About this time, he had an opportunity to buy a lot of beans at a greatly reduced price because they were damaged. He bought them and then spent all his spare time for weeks in sorting out the poor ones. In the end, he sold them at a fancy price for a good profit. Even as a lad on the farm, he raised some turkeys and invested the money received from them at seven per cent interest. He says he soon found that he could get more from fifty dollars loaned at seven per cent than he could from digging potatoes for ten days.

With his first wages, Rockefeller established the habit of giving for charitable purposes. Today, one of his most treasured possessions is a little book, called "Ledger A,"

in which he kept a careful record of all his expenditures in those early years. And with his first job he became self-supporting. A few years ago, in talking to a group of boys, he said, "It will not be long until you will be discarding your books and going to follow some life occupation. For your work you will receive a certain amount of money. Now when you have earned that money what will you do with it? Take my advice and pay your mother a part of it for your board. Use your best judgment about the rest, but always remember you cannot accumulate money if you squander it. You must be saving; you must practise self-denial."

When Rockefeller had been for three years with the company giving him his first position, his salary had risen to $700. He asked for $800 and, not receiving it, left to form a partnership with a young Englishman, named M. B. Clark. He had saved $800 and he borrowed $1,000 more from his father at ten per cent interest. These two young men began a commission business in the selling of produce, often dealing in carload lots. Mr. Rockefeller says, "It was a great thing to be my own employer. Mentally, I swelled with pride — a partner in a firm with $4,000 capital!"

The first year, the business of the firm amounted to a half million dollars. Of course, this does not mean that the profits were that amount. That was the value of the goods sold for other people. Upon this the two partners received a commission for selling. A little arithmetic will show you that, even then, the income of this young capitalist was a substantial one. And he was not yet twenty-one.

During the first year, Rockefeller found that his firm needed more capital, and he undertook to make his first loan. With much fear and trembling, he asked the president of the bank where he did business for $2,000. "All right, Mr. Rockefeller, you can have it," said the banker. "Just give me your own warehouse receipts. They are good enough for me." From that time on, Mr. Rockefeller became a great borrower, but he always kept his credit good. Some years later, he received a message at noon one day making it necessary for him to borrow a half million dollars and have it ready by three o'clock. He hurried from bank to bank in a sort of Paul Revere fashion, asking each banker to get together all the funds he could spare and have them ready when he should return. At the appointed hour the half million was in hand.

Rockefeller next went out to drum up trade and traveled over a large portion of Ohio and Indiana. Soon business began to increase so rapidly that the firm could hardly handle it.

But Rockefeller had not yet found the right business. Of one thing there was no doubt — he had chosen well in determining upon business as a career. And a vast new field of industry was waiting for someone of ability and far-reaching vision to organize and develop it. Even while yet in school in Cleveland, Rockefeller had become interested in oil. A neighbor had experimented with a thick, slimy, foul-smelling petroleum which he had skimmed from Pennsylvania creeks. Rockefeller also obtained some and began to experiment. He said, "There must be some way of deodorizing this oil, and I will find it. There ought to be a good sale for it for illuminating

purposes, if the good oil can be separated from the sediment, and that awful smell gotten rid of."

However, Drake had not then drilled that first oil well. During the Civil War times, Rockefeller formed a company for refining oil. He was quick to see that this was the most important need of the infant oil industry. But just what do we mean by the refining of oil? Some of you know that crude oil, as it comes from the well, is a mixture of liquid, solid and gaseous compounds of the elements hydrogen and carbon. To make it useful these compounds must be separated. This is done by distillation. The crude oil is heated in huge iron stills and the vapors which come off are condensed. In this way, gasoline and kerosene are obtained, and from the thick, pitch-like residue left in the iron retort, lubricating oils, paraffin and vaseline are prepared.

The first great use of petroleum was in kerosene lamps for lighting purposes. But in the first years of the industry the refining was very poorly done. Much of the gasoline was left in the kerosene. The result was a highly inflammable liquid, which easily caused explosions. Frequent fires with disastrous consequences were the result. Rockefeller saw that this business of refining must be changed to a science, and he determined to solve the problem.

As all the world knows, he succeeded, and in a short time he had formed a larger company, uniting with him in the refining business a number of prominent men. The business grew rapidly, and in 1870 the Standard Oil Company was organized. This organization, which is now the largest of its kind in the world, gradually took in

many smaller companies. In time, large refineries were established in various cities on the Atlantic seaboard, such as Baltimore, Philadelphia, Bayonne and Brooklyn. To carry the crude oil to these points, long pipe lines were laid underground, leading from the wells to the refineries. From there, the refined product is distributed in tank-cars and tank-ships to every part of the world.

Of course, this business of refining petroleum has been a highly profitable one, and Mr. Rockefeller has amassed a vast fortune. But when he was fifty-five, he retired from active business and has since devoted a great deal of time to doing good with the money he has made. In the Rockefeller Institute, some of the world's greatest scientists are devoting their lives to the study and treatment of disease. Millions of dollars are spent for this purpose every year. You who live in the South know what these men have done in conquering the disease known as hookworm, and how much this has meant to that section of our country. The great Japanese scientist, Noguchi, who recently lost his life while studying yellow fever in Africa, was in the service of the Rockefeller Institute. There are dozens of other examples.

And this oil king and philanthropist has given vast sums for education, churches, missions, public parks, juvenile reformatories and many other worthy purposes. To give and give wisely has become one of the chief concerns of his later years. He has established the Rockefeller Foundation to continue this work when he is gone.

We may think of John D. Rockefeller as having been "lucky." He happened to begin his business career just as one of our great natural resources was beginning to be

developed. But so did many others. There has been something vastly bigger than luck in this man's success. Probably better than anyone else he saw the opportunity offered and made the most of it. Added to his vision of future needs and possibilities, he had a genius for business and especially for the organization and direction of business. He had courage, foresight and great ability. These he used to build a vast industrial organization and an immense fortune. From both, the public benefits.

Coming of the Motor Age

Oil and water do not mix, but gasoline and automobiles do. We are going now to a little workshop in the back lot of a Detroit mechanic's simple home. It is a dark stormy night of the year 1895. In the dim light of a kerosene lantern, we see the tall, wiry form of a rather slightly built man of thirty-two. He is at work on a clumsy looking piece of machinery, mounted on a crude chassis supported by four rubber-tired bicycle wheels. We see him lift the rear axle and set it on blocks of wood. Quickly, he cranks the engine. The single cylinder coughs and barks, and the flywheel blurs with gathering speed. Grasping a lever, he tightens the transmission belt, and the rear wheels begin to spin.

This mechanic, lost in his work, has not noticed that the fire is burning low; he has not heard the storm; he does not know that the hands of the clock point to three o'clock in the morning. The supreme joy of achievement is crowding every other thought from his mind. For four years he has been working, and at last success is in sight.

Someone touches his arm, and he turns to see his wife in a dripping shawl and hears her say, "Henry!"

"Well, little woman, it's finished now," he says. "You wait a minute and you'll see me running it."

He opens wide the shop doors. The rain is falling in torrents on the frozen ground. But he has been waiting many a long day for this great moment, and nothing matters now. He pushes the machine into the yard and hangs a lantern on the dashboard for a headlight. He places himself on a couple of old boards nailed together for a seat. Slowly, he tightens the belt. The wheels turn, and the first Ford car begins its maiden trip.

Slowly through the yard, he moves dodging clothes-pole, posts and flower pots. He reaches the street and chug-chug turns down the avenue. His wife keeps abreast of him on the sidewalk. It is not difficult, for no speed limits are being broken. He zig-zags for a couple of blocks and begins to wonder how he is to turn around. Presently, he stops and turns the car about by hand.

Back to the shop, he creeps, closes the door on his invention, and, after drinking the hot coffee prepared by Mrs. Ford, goes to bed.

Now you want to know something about the thirty-two years that have preceded this invention.

In 1863, on a Michigan farm, Henry Ford was born. At fourteen, his mother died. Years after, in speaking of this, he says, "The house was like a watch without a mainspring."

From earliest childhood, he was fascinated with machinery. One Sunday, while the rest of the family were at church, he took apart the watch of a boy chum and put

it together again. During the long winter evenings on the farm, he poured over journals giving pictures of wonderful machines. How he longed to handle them.

Even as a lad, he built a steam engine from pieces of old iron taken from the junk heap of his father's shop. And the engine ran when he got it done.

One evening, at the close of a school day, Henry did not come home. His father and his sister Margaret, the mistress of the house, became alarmed. The hired man was sent to make inquiries. It was soon learned that the boy had not been in school, but had been seen to take the morning train for Detroit. The father worried no longer, for he knew his son could take care of himself.

Arrived in Detroit, young Ford went straight to the machine shops of James Flower and Company, where he knew steam engines were built. He had been in Detroit before and knew how to find his way. And he was sixteen now.

In reply to an inquiry, a workman pointed out the foreman, and Ford asked for a job. This man looked the strong, healthy country lad over and, thinking of the rush order he had just received, said, "Well, come back tomorrow. I'll see what you can do. Pay you two and a half a week."

Ford answered, "All right, sir," and hurried out into the bright sunshine, overjoyed at his good fortune.

His next task was to find a place to board. He tramped the streets for hours and finally located one with a kindly woman at $3.50 a week. But his wages were a dollar short of this. Clearly, he must find something to do evenings.

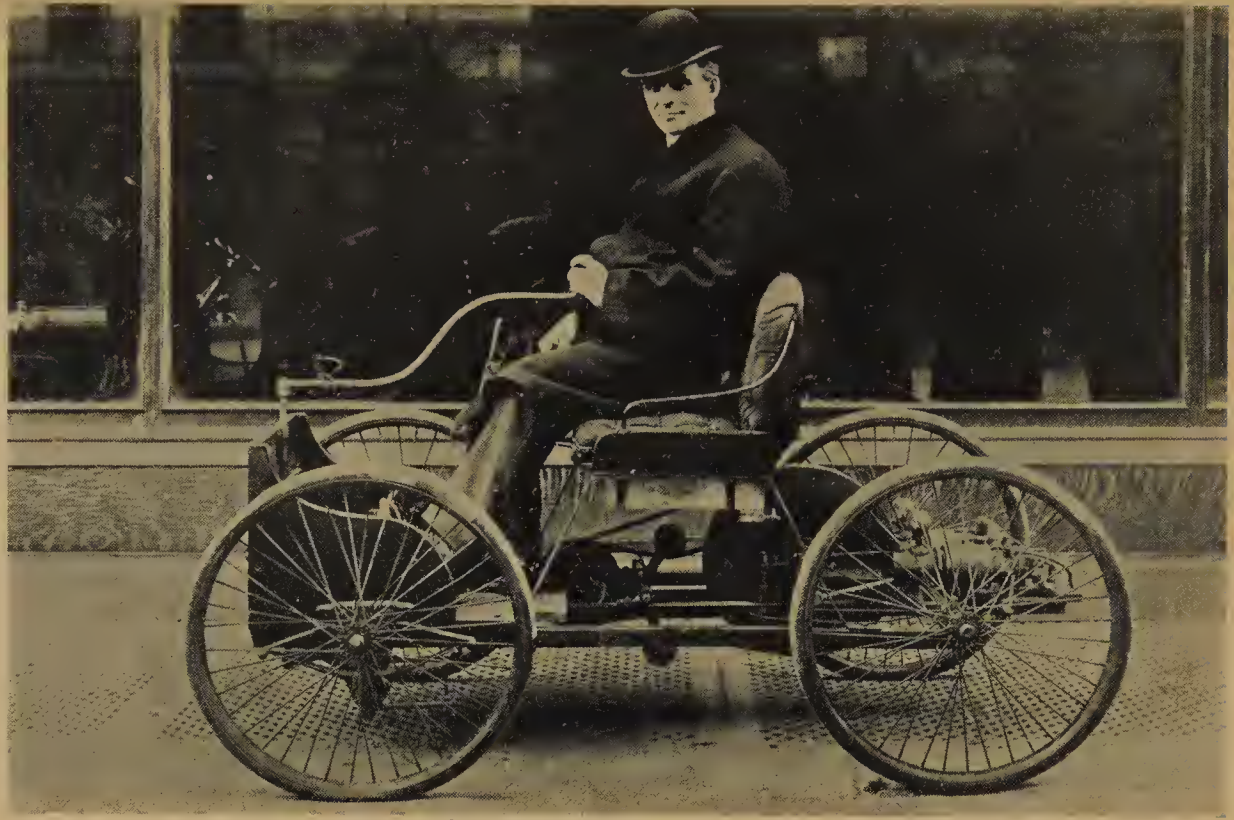
He had always been interested in clocks and watches. He thought he might find employment in a jeweler's shop. Jeweler after jeweler gave him a curt dismissal. Then, he found one willing to pay him two dollars a week for four hours each evening. This solved his problem, but it made him work sixteen hours a day, for the working day was twelve hours in those times. Some day, Ford was to change all this in that busy city by the lake.

A few days later, Ford's father found him. After a short argument over the value of going to school, his father decided it would be better to let him do the thing he wanted to do, telling him that he would always be welcome back on the farm.

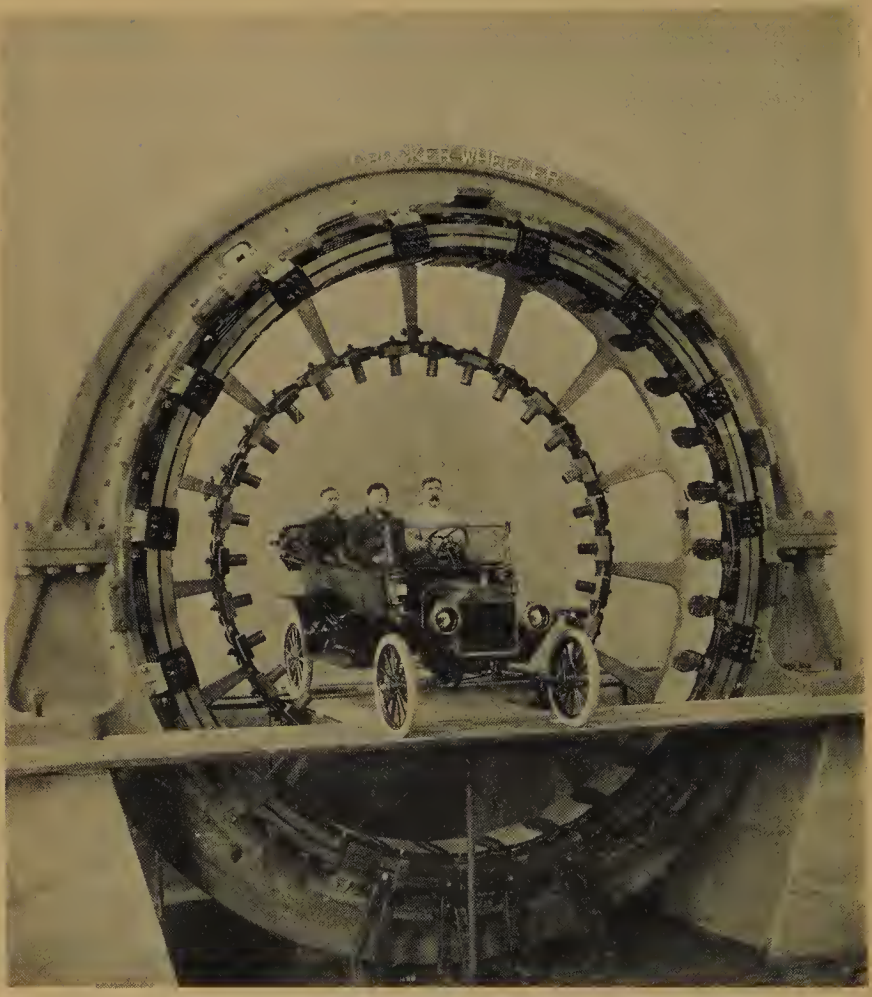
As the weeks passed, Ford became an excellent mechanic. This seemed to be the thing he was born to do. Wanting to learn about marine engines, he secured a job with the Dry Dock Engine Works, but had to go back to $2.50 a week. His wages had been raised in his first place to $3. It was not long, however, until he was getting $5, and then he gave up his evening work.

One day, he received a letter from Margaret saying that his father had been injured in an accident and his older brother was ill. There was nothing to do but give up his dream of starting a factory to manufacture watches at the rate of two thousand a day and to be sold at fifty cents apiece. He immediately returned to the farm.

The weeks and months slipped by, and he told his father he had decided to remain on the farm. In 1888, he was married and built a home on forty acres of land his father had given him. Still, he was always reading and dreaming of machinery.



Henry Ford and his first car



Giant field frame of huge dynamo in the Ford Plant. It is 21 feet high and 26 feet across the base

One evening, he said to Mrs. Ford, "I saw an article in that French magazine that came the other day about a Frenchman who invented some kind of carriage that runs by itself, without horses — sort of steam engine to pull it."

From that idea, he could not free himself. He kept wondering how he could build a steam engine to take the place of horses on the farm. How he could make it light enough was the thing that bothered him. The great quantity of water necessary to form steam seemed to be the stumbling block. Then, one day, the thought flashed into his mind, "Why not use gasoline?" So far as he knew, no engine using this kind of fuel had ever been invented.

He saw at once that he could not build an engine there on the farm. Against the strong opposition of his family and the advice of Mrs. Ford, back to Detroit he went. He knew he must know more about electricity to bring his dream to pass.

On arriving in the city, he left Mrs. Ford to find a place to live, and he headed for the plant of the Edison Light and Power Company. Fortune favored him. One of the engines had broken down, and no one seemed to be able to fix it. The superintendent looked the "tramp engineer" over and asked him what he could do. Ford said he would like to have a try at the balky engine. This was at ten in the morning. At six that evening, the engine was running smoothly and the dynamos humming.

Asked if he would like the job of night foreman at $45 a month, Ford answered, "Go to work right now if you

say so." Soon he was manager of the mechanical department at $150 a month.

Ford now built a home and began the four years of night work which resulted in the car we have already seen. Still, eight years more were to pass before anything like automobile success was to arrive.

Day after day he worked in the Edison light works and night after night he spent in his shop improving his car. In those long evenings, he made the acquaintance of "Coffee Jim," the keeper of a small restaurant, where he used to go for an occasional midnight lunch. Coffee Jim became enthusiastic over the car. When he discovered that Ford could not build a car to compete in the coming races, because he did not have the capital, he supplied the money. As a result, Ford left his job and began the building of a two-cylinder car.

The day of the races arrived. Alexander Winton with his car, which up to that time had beaten in every race, was the center of an enthusiastic group of admirers.

Looking toward the newcomer, people said, "Who's that?"

"Oh, he's a man from Detroit, named Ford. Never heard of him before. Queer-looking car, isn't it?"

The race began. Mrs. Ford and Coffee Jim were in the grandstand. Round the track, the two cars went, Ford to the amazement of everyone keeping just behind the champion. On the second stretch, Winton shot ahead. The crowd roared. But wait. What is happening? The little car gains. Into the third lap they speed by the grandstand neck and neck. The crowd grows

wild with excitement. Ford is ahead and remains so to the end.

"Ford! Ford!" was on every tongue. Hundreds crowded about, sportsmen, reporters, camera men, and the admiring multitude. Ford was famous.

Ford now received offers from wealthy men who wanted to supply capital to build an expensive car to sell at a big profit. This was not Ford's idea. He wanted to build a simple car to sell at a moderate price — a car which everyone could afford to own. He rejected their offers.

Among those who had seen Ford's triumph were James Couzens, a thriving merchant of Detroit, and Tom Cooper, a champion bicycle rider. They encouraged the new champion to build a bigger car for the races at the Grosse Point tracks in the following spring. Cooper supplied the money. When it was complete, Ford had a monstrous four-cylinder car of eighty horsepower. Nothing like it had ever been seen before. They secured Barney Oldfield to drive it and in a famous three-mile race he won by half a mile.

This feat startled the world, and offers of capital poured in. Still, the idea was for a big expensive car. Ford could not agree. Finally, with the help of Couzens and another man named Wills, he started a little plant and began to turn out cars. Their price was $900. The cars sold, but the capital of the company was small, and often Ford could not pay his men until he had received money from his cars.

At the first Christmas, there was no money in the treasury. Ford called his men together and told them the situation. He asked them to stand by him until the tide

turned. They did so. The day before in a test on the frozen surface of Lake St. Clair, he had made a mile in 39⅘ seconds, clipping 7 seconds from the world's record. Orders began to tumble in faster than the plant could fill them. And money too. Never again was there a shortage of funds in the Ford Company.

And Ford remembered his men. Just before the Christmas of 1908, he and Couzens sat in their offices going over the business of the year. Profits had been large. Ford was already a millionaire.

Suddenly, Ford said, "Now we have some money we don't need for the business, we ought to divide with the men. Let's do it." "I'm with you!" Couzens answered with a will. That Christmas every man from manager to office boy received an extra check in his pay envelope. The following month broke all January records in turning out cars, and in that year Ford exceeded his dream of 10,000 cars a year.

At the beginning of 1914, the automobile manufacturer announced a minimum wage of $5 a day and an eight-hour day. Other leaders of industry called him "crazy." The results tell. In January of the preceding year, 16,000 men working ten hours a day built and shipped 16,000 cars. In January of 1914, 15,800 men working eight hours a day produced 26,000 cars.

Ford, too, has passed on a part of his profits to the public in the form of price reductions in cars. Of course this in turn increased sales. He was one of the first in this country to see that a large volume of business on a small margin of profit is better for everyone.

One of this man's hobbies is that of employing ex-

convicts. He has several hundred in his shops. If he needs the service, he will give any man who wants it a chance to make good.

Of course, Ford has made mistakes. We all do. His famous peace trip during the Great War, of which you have probably heard, was a wonderful piece of idealism. But even before it started there seemed no hope of success. His attack upon the Jews, for which he has since made amends, showed him lacking in sound judgment outside of his world of business. Although he has dealt generously with his men and fairly with the public, he has shown no interest in becoming a philanthropist. But there is time yet.

His present hobby is that of collecting antiques and acquiring possession of historic sites. He has a large estate of 4,000 acres close to his boyhood home. His tastes are simple. He has been unspoiled by large prosperity and great wealth.

Of course, there were other pioneers of the automobile industry in America, George B. Selden, Charles E. Duryea, Elwood Haynes, Alexander Winton, Apperson, Packard, and others. Some of them preceded Ford. But to Ford belongs the supreme credit of having placed the automobile within reach of the common man. Without his achievement, cars would still be the luxury of the rich. He brought the automobile age to pass.

Now I think you will agree with me that there has been an empire in oil and cars.

CHAPTER III

A GROUP OF FINANCIERS

FINANCIER is a big word. Let us see what it means. Robert Morris was the financier of our War of Independence. He was a wealthy man for those times, and a banker. You have read how in the darkest days of those trying years he brought new courage to the struggling colonists and saved the American cause by supplying Washington with much needed funds. In a smaller way, Benjamin Franklin was a financier. He amassed a considerable fortune and won for this country the military and financial assistance of France.

Alexander Hamilton was our first great financier after we became a nation. As first Secretary of the Treasury, in Washington's administration, he insisted that the Government pay the national debt — all the money that had been borrowed to fight the war. He, too, worked out a sound financial system for the young republic. In the words of Daniel Webster, "he smote the rock of national resources, and abundant streams of revenue gushed forth. He touched the dead corpse of public credit, and it sprang upon its feet." Never after that did anyone, either at home or among foreign nations, fear to trust the United States. It is just as important for a nation to pay its debts and to

have ample sources of income as it is for a person to keep his money affairs in good shape.

And so a financier is one who deals in money, stocks, bonds, and other evidences of property and wealth, much as a merchant buys and sells all sorts of other commodities. In many ways, to which we usually give little thought, financiers are necessary to the running of our government and the business prosperity of the nation. Men who handle big business undertakings, such as Carnegie, Wanamaker, Rockefeller, and Ford, must at times have the assistance of bankers, and bankers are our most important financiers.

Probably the greatest financier, or banker, in this country since the Civil War was J. Pierpont Morgan. No one, except the older readers of this book, will remember him. He died in 1913, shortly before most of you were born. It was as natural for the youthful Morgan to turn to banking as a profession as it is for many a country lad to become a farmer. His father, Junius S. Morgan, was first a merchant of Boston and afterward a member of the great London banking house of George Peabody and Company, later becoming its head. The business of banking surrounded Morgan in his boyhood, as automobiles do the son of a garageman. He seems never to have had a doubt as to what he should do when he became a man. In these days many of us do, and it often seems more difficult now for a boy or girl to choose wisely.

Morgan was born in Hartford, Connecticut, in 1837. His grandfather, Joseph Morgan, owned a hotel there and was a prominent man in the community. His grandfather on his mother's side was the Rev. John Pierpont,

a noted New England preacher and writer of hymns. Although seventy-six when the Civil War came, he enlisted as a chaplain in the northern army and served for a time. Young Morgan graduated from the English High School in Boston and then studied at the University of Göttingen, Germany.

At twenty, in the year of the great business panic of 1857, Morgan entered the banking house of Duncan, Sherman and Company, one of the most famous in New York. In those first years, this youthful banker gave little promise of the big things he was soon to be doing. It is said that, so poor an impression did he make on his superiors, he was asked to resign. But Morgan had been all the while a serious student. He had been a keen observer and had learned much about the ways of banking. Almost immediately, he organized his own banking house, known as Dabney, Morgan and Company, and soon won the applause of the banking world by reorganizing a bankrupt railroad and putting it upon a firm financial footing. This was the Albany and Susquehanna Railroad, a road which had been wrecked by the dishonest methods of Jay Gould.

All through his life, Morgan was busy doing similar things. Time and again, he rescued railroads and other large enterprises from the most serious financial difficulties. It was not long until he came to be known as one of the great bankers of the country. Twice, in times of crisis, he was of the utmost assistance to the Government and the whole financial world. In the great business panic of 1893, he saved the credit of the nation. Again, in 1907, when ruin seemed the lot of hundreds of banking

houses and business enterprises throughout the country, bankers everywhere turned to Morgan. Almost single-handed, he checked what might have been widespread disaster.

Why was it possible for Morgan to do this? Why did the leaders of industry and finance turn to him instead of to the President of the United States and the members of the Government? Because he was the country's foremost banker. He understood money affairs and how to deal with them better than anyone else. He knew the financial condition of the country as no other man did. And he possessed great wealth and exercised a tremendous influence. Still, he might have had all these qualifications and yet not been chosen to lead his fellow bankers and business men out of their distresses. Most important of all, Morgan was a man of the highest integrity. Men trusted him. Even his enemies, of which he had many, had the utmost confidence in his rugged honesty. They knew that his wide knowledge and great power would be used for the best good of all. He left no prouder legacy to his family than this implicit faith in him as a man, in this hour of national peril.

It was said of him, "His house is the repair shop to which the crippled must go." He maintained a sort of financial garage for the rebuilding of broken industries.

There was another side to this man Morgan. He was a great lover of the beautiful. His art treasures, for which he often paid fabulous prices, are among the choicest ever collected. The rarest paintings, works of sculpture, old books and manuscripts, pieces of bric-a-brac, porcelain, tapestries, and much else came into his possession. He

kept them in his magnificent private library in New York, in the Metropolitan Museum of Art, and in museums abroad. Frequently, they were placed on exhibition for the benefit of the public. He wanted others to share his pleasure in these great masterpieces.

Of his great wealth, he gave generously, but the world will never know the full extent of these gifts, for he shunned publicity. The Harvard Medical School, the Lying-in-Hospital in New York, the Cathedral of St. John the Divine still in the process of erection, St. Paul's Cathedral in London, the New York Trade School, the Metropolitan Museum of Art, are just a few of the institutions which have profited from this man's desire to use his money for good. And he also gave of his time. To the affairs of his church and the public bodies of which he was a member, he gave the same serious attention which he devoted to his large business interests.

And now I think you know something of what a financier is. We have no more splendid example in this country than that of J. Pierpont Morgan. His son, bearing the same name, now heads the famous banking house, and a grandson is being trained to succeed in the years to come.

From Farm-Lad to Banker

A LITTLE more than a half century ago, a boy might have been seen on an Illinois farm, faithfully tending a drove of thirty-seven calves during a summer vacation. For this summer's work, he received twelve dollars, and what do you suppose he did with the greater part of it? He did

not buy fishing tackle, gun, or skates, as many boys would have done. Instead, he answered an advertisement offering the *New York Weekly Tribune* for five years and a Webster's Unabridged Dictionary. These cost ten dollars. They seemed the most important possession he could obtain for his money. He had then read everything that his home offered, including the Arabian Nights, a complete set of Shakespeare, and a few magazines.

That boy was Frank A. Vanderlip, formerly president of the National City Bank in New York, the greatest bank in the country. How did he rise from that Illinois farm to be one of our great financiers? Let us see.

When this boy was twelve, his father died, and four years later his mother sold the farm and moved to Aurora, a nearby town. Because his earnings were needed to help support the family, he could not continue his education. Instead, he took a job in a machine shop at seventy-five cents a day. To fit himself for something better, he studied draughtsmanship and mathematics in his spare time, tutoring shopmen in other subjects to pay the expense. Finally, he decided that he must go to college for at least a year. Entering the University of Illinois, he completed a course in mechanical engineering, working on Saturdays as a machinist to help pay his board and lodging. However, this was a short course, requiring only a year.

Disappointed at not being able to secure a position with Edison, to whom he wrote, Vanderlip went back to the machine shop at $1.35 a day. In his spare time, he studied shorthand, and, it is said, that as he worked at the bench, he practised writing characters in chalk on flat pieces of iron, much as Abraham Lincoln used the blackened shovel

by the fireplace for a slate. This work emancipated him from the bench and led to a position on the local paper at $6 a week, not big pay but a stepping-stone, he felt, to something better. And so it proved.

Vanderlip continued his self-education, while he was acting as reporter, by studying subjects having to do with banking and finance. Soon a friend from his home town who was at the head of an agency in Chicago which supplied bankers, brokers, and other business men with important financial information gave him a position as stenographer. In three or four years, he became head of the agency, his friend, Joseph F. Johnson, having become financial editor of the *Chicago Tribune*. This was followed with a job as reporter on this paper, and so capable did he prove to be that at twenty-five he found himself in the financial editorship itself. He had now risen to a place of some importance in the newspaper and financial world of the mid-western metropolis.

In his new position, Vanderlip became the relentless foe of men who sought to make money at the expense of the public welfare. Time and again, he exposed the dishonest practices of these men. Soon the whole city came to know this fearless young man who dared to risk his fortunes to fight their cause. The leading business men recognized his ability, and when Lyman J. Gage, a prominent banker of Chicago, went to Washington as Secretary of the Treasury in President McKinley's cabinet, he took Vanderlip with him to be his private secretary. In a short time, he was made Assistant Secretary of the Treasury and placed in charge of the 5000 employees in the treasury department.

While in this position, Vanderlip was given the handling of a large loan of $200,000,000 needed by the Government to fight the Spanish American War. So ably did he do this work that he attracted the attention of the leading bankers of the nation. At the end of his term of office, James Stillman, head of the National City Bank in New York, asked Vanderlip to become a vice-president in that large financial organization. He was now thirty-seven and had risen to one of the most important banking positions in this country. We see how it was done. Step by step, he had pushed forward, winning every time because of hard work and genuine merit.

Largely because of the new ideas brought by Vanderlip to the City Bank, it grew marvelously, and in less than ten years he was made president.

One of this man's hobbies has been that of helping poor boys. On his country estate on the Hudson, he maintains a private school, where many are given free tuition. But Vanderlip did not wait until he was a rich man to do this. Even as a struggling young man in Chicago, he was doing much to help those less fortunate than himself. Many a poor waif from the Chicago streets was sent to the country during the summer because of his generosity. Others were remembered with Christmas gifts.

During the Great War, he did heroic work in helping to make the Liberty Loans the great success that they were. I am sure you will agree that this boy who invested his first earnings in a newspaper and a dictionary has turned out well.

A Youth Who Would Not Accept "No"

Some forty years ago, a young man entered the office of the cashier of a newly organized bank in New York and asked for the position of paying teller. The bank had not yet opened for business, and this particular young man very much wanted such a position in New York City. Indeed, he felt that he must have it. Having a letter of introduction from a mutual friend, he received a cordial welcome. However, he did not get a promise of the coveted position.

More determined than ever, the next afternoon again found him in the banker's office. This time the banker explained that they must have someone for this position who had had experience in New York City. This young man had never lived or worked in New York. The banker dismissed him in a kindly way, but made it clear that the position would not be open to him.

The more the young man thought about it, the more convinced he became that there was an opportunity that he must not let go by. At the close of work the next day, he boarded a train for New York, for he did not live in town. This time he found the banker had gone for the day. He asked where this gentleman lived and immediately went to his home. The servant told him that the banker was dressing for a dinner engagement. The young man said he would wait. Again he urged his case and assured the banker he knew he could make good. So impressed was the man with the persistence of this pleasant-faced, good-natured youth that he promised him the much-sought position, at a salary of $1,500 a year.

So elated was he that he went out into the street treading on air. Even a few days later, when he received a statement that the directors had objected and made a request that he accept a somewhat lower position at a reduced salary, his enthusiasm did not cool. What he wanted was an opportunity to work and demonstrate his worth in a banking house in the great money center of America.

This young man was Henry P. Davison, then a receiving teller in a bank in Bridgeport, Connecticut, and later regarded as one of the world's greatest bankers. In fact, he was so regarded for more than twenty years. At forty, he was chosen by J. Pierpont Morgan to be a partner in the great banking house of which we have already learned. Probably never before had anyone risen to so great a position in the banking world at so young an age. Morgan is the only man to compare with him.

We have seen one reason why Henry P. Davison succeeded. Such perseverance as he displayed would break down barriers of steel. And, of course, he had great ability. Those qualities won for him rapid promotion. Within a short time he had been given the much-coveted tellership in the bank of his first choice. Soon after, he was made assistant cashier in another large New York bank, and four years later, at the age of thirty-two, he became its president. Within five years he had risen to one of the foremost positions in the great banking community of New York. And there had been no influence or "pull." Henry P. Davison stood on his own feet and won by pure merit.

In the founding of the great Federal Reserve system,

which makes this country now largely free from disastrous business panics, Davison had a large part. And he did many other notable things.

Henry P. Davison was born at Troy, Pa., in 1867 and at the age of seven became an orphan. For lack of money, he was unable to go to college, although he had prepared for entrance. Instead, he went to New York to find a job, and failed. He went on to Bridgeport, Connecticut, and there became a runner in a bank. In odd moments, he learned to do the work of the bookkeeper, and when the bookkeeper was promoted young Davison took his place. In the same way, he learned the duties of the teller, and it was not long until he had secured that position. There and later in his career, he was always preparing for the job ahead.

There is no secret regarding the success of men like Morgan, Vanderlip, and Davison. And the same qualities will win today just as surely as they have in the past.

A Financier for the Nation

Let me tell you of another financier, a man of whom you all know, Andrew W. Mellon, Secretary of the Treasury in the administrations of Presidents Harding, Coolidge, and Hoover. Like Morgan, Mellon was the son of a banker. He naturally became a financier.

When he graduated from the University of Pittsburgh at the age of nineteen, his father sent him to a neighboring city to start a real estate business. In this venture he was so successful that his father soon took him into the bank. Gradually, his business interests extended to the great

industries of coal, coke, iron, and oil. He has built a petroleum organization second only to that of the Standard Oil Company. He, too, has been a big factor in developing the aluminum industry of this country.

During these years, Mr. Mellon has added to the fortune left him by his father until he is counted one of the wealthiest men in America. He uses his great wealth for the public good and gives large sums for charity and other worthy purposes. His most notable gift is that of the Mellon Institute, founded by him and his brothers in honor of their father. This Institute, located in Mr. Mellon's home city of Pittsburgh, is a great research laboratory, where scores of scientific problems having to do with the improvement of industry are being solved by trained scientists.

It is as Secretary of the Treasury that Mr. Mellon has performed his greatest service. Taking charge of the money affairs of the United States is the biggest financial job in the world. Seldom before has this country been so fortunate as to have a man of Mr. Mellon's wide experience in business and banking in this position. And let us remember that service to his country is the motive which prompts a man of Mr. Mellon's vast wealth to accept such a position. This position, too, is one which means hard work and much of it. One who keeps constant tab on the financial condition of this country has few idle moments, and this Mr. Mellon has done with great faithfulness and the highest ability.

Secretary Mellon's father, Judge Thomas Mellon, was a poor boy who came to this country from Ireland and settled in Pittsburgh. There, he studied law and became

a successful attorney and judge. In 1869, he founded the banking business which his sons now continue. All have been interested in helping young men to success, and many have profited by their generous assistance.

One of a Race of Financiers

Some of the greatest financiers of our country have been members of the Jewish race. I am going to tell you something of one of the most eminent of them, Jacob H. Schiff. If you were to learn the names of the great private banking houses of America, you would soon discover that the house of Kuhn, Loeb and Company is one of the oldest, with a proud record of big undertakings and large usefulness. For many years Mr. Schiff was the head of this great financial organization.

He was born in the famous city of Frankfort-on-the-Main in 1847. His family was neither rich nor poor. One branch of it was engaged in the banking business, and young Schiff early became interested in finance as a career. During our Civil War, he came to America. After a short apprenticeship as a clerk in Wall Street, he and another young man formed the financial firm of Budge, Schiff and Company to deal in stocks and bonds. From the first, he prospered and soon joined the firm of Kuhn, Loeb and Company. A few years later, he married the daughter of Mr. Loeb, and when, in 1885, the latter retired, Mr. Schiff succeeded him as head of the firm.

It was Mr. Schiff who supplied Harriman with the money to rebuild the Union Pacific Railroad. He also provided large sums to assist in the building and exten-

sion of other railroads. Growing industries must have millions of dollars, and often they must borrow. Great banking houses, such as that formerly headed by Mr. Schiff, raise money for these purposes through the sale of stocks and bonds to the public. Those who buy them become partners in the business and sharers in its profits, drawing interest, called dividends, upon their investments. These stocks and bonds are called securities, and the banking house receives a commission, that is, a certain percentage, for selling them.

Probably no other member of his race in this country gave more for philanthropic purposes than did Mr. Schiff. Colleges, libraries, hospitals, the Red Cross, the New York Chamber of Commerce, and many other organizations have benefited from his gifts.

And Mr. Schiff placed his American citizenship above loyalty to his own race and its institutions. That was his most highly prized possession. A worthy member of a people who are doing much in the building of America, Mr. Schiff was a financier of whom any country might well be proud.

This country has many other great financiers who can not even be mentioned in this little book. But I want you to know what a financier is and something of the important work which he does for his country's business and industrial prosperity.

CHAPTER IV

THE CONQUEST OF THE POLES

DID YOU ever long to penetrate some dark and lonely forest, to climb some rough and forbidding hill, to lose yourself for the time being on the broad expanse of the deep blue sea or to roam, free as the air, over the great open spaces of vast prairies? If so, and what boy or girl has not? — something within you has answered to the "call of the wild," a call as old as man himself. But have you also yearned to explore the unknown and wished that more of this old earth were in a state of primitive wildness? Have the jungles of Africa or the Amazon or the desolate wastes of Siberia ever challenged the spirit of conquest within you?" "Yes?" Then, you are kin to that small army of brave adventurers in every century who have given their energy, their heart's devotion and ofttimes their lives in the cause of arctic and antarctic exploration. It is about several of these heroes of the frozen wastes that I wish to tell you now.

First, let us answer the question, "What good do these explorations do?" To one who thinks in terms of decades only, probably none. But suppose we stretch our imaginations to include the centuries and the ages. Where would America and the New World be today,

had not Columbus longed to find what lay beyond the western horizon of the great ocean? True, he believed it was the East Indies, rich in natural wealth. Still, it was the unquenchable spirit of conquest that lured him on. What boy or girl has not read tales of Daniel Boone and the "dark and bloody ground," of Lewis and Clarke and that historic expedition of discovery which added a new empire to the domain of our country, of the explorations of Livingston and Stanley in darkest Africa, and of many other perilous journeys in search of the unknown? In every instance, there were many who asked, "What is the use?" But I do not have to answer this question for you now. You know that without what these men did much of this earth would still remain a howling wilderness.

But arctic and antarctic explorations are different, you say. These regions are utterly uninhabitable. So far as we know, they have no great sources of natural wealth. Why should men care to bother about them? Why did Peary, at the sacrifice of shortening his life, wish to plant the Stars and Stripes at the North Pole? Why did Captain Robert Scott and his brave comrades willingly give their lives as true Englishmen, victims to the terrible cold of antarctic wastes? What animates men deliberately to face such peril? The answer is the challenge of the unknown. Men will never rest content so long as any portion of this earth remains unexplored. And, though such exploration may make no fortunes, it helps men to grow in true greatness. Who has not been thrilled by the example of heroism and valor set by these intrepid conquerors of the earth's last strongholds? The measure of life's

values is not always in gold and silver. Its greatest wealth lies in the treasures of the spirit.

Yet, wait a moment. Possibly these explorations do have value. Do you know that the "cradle of storms" in the northern hemisphere lies in the frozen north? Likewise in the southern hemisphere. When men know more about the mysteries of temperatures, air pressures, and winds in these vast centers of weather disturbances, the dream of long-range weather forecasting may become a reality. And again, do you know that the shortest and probably the safest aerial route from America to the Orient lies over the arctic seas? Some day a great line of airplanes, and possibly of giant airships, may bring New York and Peking almost as close together as New York and San Francisco? To make this dream come true, weather stations must be established in these parts, and such stations can only follow where the explorer leads the way. A chief purpose of such expeditions as those of Admiral Byrd and Captain Wilkins is to gain knowledge of the weather and to establish points of observation. Even measured by the world standard of usefulness, polar exploration is worth all it costs.

"The true explorer does his work not for any hopes of reward or honor, but because the thing he has set himself to do is a part of his being, and must be accomplished for the sake of the accomplishment." This is the reason Admiral Peary gave for a life devoted to arctic exploration.

Although born in Pennsylvania in 1856, Peary's father having died when he was three years old, his mother took him to Maine, where his ancestors had lived the hardy

pioneer life of woodsmen in the primitive forests of the Pine Tree State. There he attended Bowdoin College, from which Nathaniel Hawthorne, President Franklin Pierce, and the poet Longfellow had been graduated at an earlier time. In 1877, he received the degree of civil engineer, graduating second in a class of fifty-one.

Even as a lad, Peary had been fond of tales of adventure. One such tale stirred his young imagination more than any other. It was Dr. Elisha Kane's wonderful story of his voyages in the Arctic Ocean. Even in his college days, he passed many happy hours in reading the thrilling accounts of other explorers in that little-known region of ice and mystery. From the fascination and lure of it all, he could never free himself.

In his youth, without knowing it, he had prepared himself for the intense physical exertions which were to be his lot in later life. He loved the outdoors and the open sea, and he learned the ways of both. He became a skillful hunter and obtained a knowledge of boats. With boyish pride, he prepared and mounted the specimens which he shot. This active life, close to Nature, gave him the physical endurance with which to meet future hardships.

Following college, four years passed amidst the hills and forests of Maine, with Peary leading the unexciting life of a country surveyor. Then, he became a civil engineer in the United States Navy and moved to Washington. Soon, he was sent as assistant engineer to the jungles of Nicaragua to survey a route for a Panama Canal. But, even in the midst of the tropic heat of a malaria and yellow fever infested country, he continued to dream of making

long journeys by sledge over the windswept, icy wastes of the great polar regions. Today, in the American Museum of Natural History in New York, one may see the battered sledge with which he made his successful dash for the pole. Dreams, backed by the energy and steadfast purpose of a man of Admiral Peary's type, do come true.

One evening, Peary chanced to pick up a paper which gave a partial description of the great Greenland ice sheet, so terrible in its intense cold and storms that the natives did not dare to venture upon it. He determined to see this land of mystery for himself. He obtained a leave of absence from Washington, and in the summer of 1886 made his first visit to the "Arctic Sahara," as he called it. For many miles, he traveled inland, the awful stillness broken only by the noise of the sledges. At last, his keen fascination for the ice-bound land of the North was to some small extent being satisfied. He made many notes and charts during his short stay, but the following autumn found him back in Nicaragua.

Two years passed and Peary was stationed at the League Island Navy Yard, near Brooklyn, New York. The Geographical Department of the Brooklyn Institute had learned of his trip to Greenland and invited him to speak at one of its meetings. The evening was cold and wet and only a few came out to welcome the young explorer. Although seemingly an unimportant incident, this meeting was destined to mark the beginning of a new day in arctic exploration. A long account of Peary's address was published in a Brooklyn paper. This came to the attention of the Philadelphia Academy of Sciences. As a re-

sult, Peary became in 1891 the head of another Greenland expedition, larger almost than any of which he had ever dared dream before.

He was now married, and with five others besides Mrs. Peary and the crew he set sail on the *Kite* for the " White North." On and on the small but good ship sailed, past the coasts of Labrador and then to Greenland. At length, only bare rocks were seen along the shore line, and lonely icebergs and immense masses of floe ice appeared in the water. In forcing a passage through the pack ice one day, a sharp heavy blow on the rudder swung the iron tiller about, catching Peary's leg between it and the pilot house. The result was a bad break, which did not mend for many weeks.

Finally, a house was built on the mainland from materials brought on the ship, and the *Kite* sailed southward to return in the following autumn. It was then the beginning of winter and the long nights of the far North. The men spent much time in hunting to supply furs and add to the stock of food. Reindeer, walrus, and seals were plentiful, and the friendly Eskimos taught them how to hunt and to make fur clothing. Fierce storms raged from time to time about the little house, and sickness once attacked its occupants, but it did not stay and, best of all, Peary's leg day by day grew better.

Slowly, the winter passed, and by the end of April the long awaited day for the beginning of exploration arrived. With three men, a number of Eskimos, and twenty dogs, Peary set forth. Although summer was approaching, only drifting snow, terrible storms, and a vast expanse of ice greeted the explorers. When one hundred and thirty

miles had been covered, with a single companion, a young Norwegian, Peary proceeded alone. The fewer the number, the surer he was of success. Day after day they pushed on. At length, mountains loomed ahead of them, the sound of cataracts filled the air and lakes and rivers lay spread out in the valley below them. They had crossed the great Ice Cap.

Soon the hot June sun was beating down upon the two men. They now suffered almost as much from the heat as they had done from the cold. Tracks of animals appeared in the soft earth, and Peary knew that musk-oxen were at hand. It was not long until they had shot one, and the supply of fresh meat gave new life both to the dogs and the weary travelers.

More mountains appeared ahead, but Peary and his comrade would not turn back. They wished to find the ocean, and on July Fourth they came to it. The water before them, Peary named Independence Bay. Flowers were everywhere in blossom, and the hum of a honey bee told them that summer had come, even to the north shore of Greenland.

Now, the explorers turned back, to make their way once more through blinding snow and intense cold to the little house where Mrs. Peary and their comrades were awaiting them and where they hoped the *Kite* would also be. After much hardship they arrived safely, and in due time the exploring party was back in America.

The lure of the North was now strong upon Peary, and he soon found himself leading another expedition into Greenland. On this trip, "the Snow Baby," the first white child born in the frozen northland, came to the

house built close to the edge of the great ice sheet. Before he returned, too, from the second crossing of the Ice Cap he almost lost his life from hunger and cold. On his way, he discovered some immense meteorites, which he later brought back with him to the Museum of Natural History in New York.

Now a still larger project was taking shape in Peary's mind. He wished to reach the North Pole. The Peary Arctic Club was formed in New York, and, beginning in 1898, he led one party after another northward from the Greenland shores. Still, the goal was not reached. Then, the *Roosevelt,* the staunchest ship for arctic exploration ever built up to that time, was made ready for him. The first voyage, after terrific hardships, failed. To raise money for a second, Peary spent much time in writing and lecturing. This was in 1905. Three years were to pass before he should set forth on his eighth arctic expedition. Most elaborate preparations were made. Every imaginable precaution was taken. Not a loophole for failure was left anywhere. At last, in July, 1908, the *Roosevelt* sailed once more. At Cape Sheridan, the party camped for five months.

In February, Peary set out for Cape Columbia. He had with him sixty-six men, one hundred and forty dogs and twenty-three sledges. Gradually, he reduced the number of men to only five, with the proper number of dogs and sledges, sending the others back to the main camp. Finally, when within one hundred and thirty miles of the Pole, with only one comrade, four Eskimos and five sledges, he made his final dash. In five days of awful struggle, battling every mile of the way against

terrible odds, on April 6, 1909, his own fifty-third birthday, he planted the Stars and Stripes at the North Pole.

Gaunt, worn almost to shadows with fatigue and cold, even the dogs resembling mere ghosts of their former selves, Peary and his men, buoyed up with a wonderful happiness, made their way back to the *Roosevelt* and, as rapidly as the ship would bear them, to their country, for whose honor they had suffered so much.

Peary was now made a rear admiral in the United States Navy, and geographical societies of his own and other lands awarded him medals and honors. He continued to lecture and write and became much interested in air navigation. In 1920, he died, rich in the thought of having won a great triumph and in the well-earned esteem of his fellowmen.

A Modern Viking

With the North Pole conquered, men turned their thoughts with ever-increasing earnestness toward the vast unknown areas of the Antarctic. Who would be the first to reach the South Pole and what country's emblem would first fly there? In Norway, that land of seafaring people which for centuries has supplied some of the world's boldest navigators, was a man who said, "The flag of my country shall yet be planted at the South Pole, and I will be the one to do it." That man was Roald Amundsen, whose tragic death in a valiant and never-to-be-forgotten attempt to save the life of a former comrade, lost in the arctic wastes, forms one of the most recent

and vivid chapters in the rapidly moving drama of air navigation.

In Amundsen's veins flowed the blood of the ancient Norsemen. He was born close to the sea, and his father was a ship owner. From his earliest years, he had listened to tales of adventure and daring exploits of hardy seamen before the mast. He was accustomed to the biting cold of northern winters, and the tang of salt air was to him as the breath of life. Young Amundsen came to love the ocean with a love that grew with the years.

Although Amundsen first studied medicine, he could not put aside the call of the sea. At first a common sailor, by the time he was twenty-five he had become mate on a vessel named the *Belgica* and sailed on a long voyage to antarctic waters. Four years later, he turned his voyages toward arctic regions. In 1903, he undertook his first real expedition of discovery in the little bark *Gjöa*. He was now captain, and he was gone three years. He studied the deep waters about Greenland and did much hunting. Observations with the compass needle enabled him to add much to our knowledge of the earth's magnetism in the vicinity of the North Magnetic Pole. The Eskimos taught him and his comrades how to build snow houses. Beautiful beyond description were the brilliant displays of "Northern Lights" in the clear cold skies of the northland. Finally, the first winter passed and spring came, followed by an abundance of bright flowers, through which gay butterflies and honey bees flitted, and overhead birds once more flew. Quickly, the summer sped by and another winter; still, Amundsen had not yet accomplished the real purpose of the expedition. He wished with all his

heart to find the famous Northwest Passage from the Atlantic to the Pacific, for which so many bold navigators had sought in earlier centuries.

With the opening of the second summer, Amundsen sailed forth on his great search. Winter overtook him, and he and his men made themselves comfortable on a friendly shore abounding in driftwood and game. There, lost to the outside world, for this was before the days of radio, these men lived the wild free life of the pioneer and the explorer. Great happenings might be taking place back in Europe or America, but of them they knew nothing. Snow and ice, fierce storms, bright sunshine, starry skies, vast, silent spaces — what a land!

With the coming of spring, once more the *Gjöa* weighed anchor. The voyage became more difficult. Sharp turns and narrow passages called for the utmost caution. At length, on August 31, 1905, the little ship arrived safely at Nome, a gold diggers' settlement on the coast of Alaska. The Northwest Passage had been found, and Amundsen had made himself famous. When upon his return the news was heralded to every land, he became a world hero.

After Peary had reached the North Pole, Amundsen's thoughts began to turn southward once more toward the vast unknown areas of the Antarctic. In the summer of 1910, he set out for the South Pole. This time his ship was the *Fram*. In the autumn of the same year, Captain Robert Scott left New Zealand on a similar voyage of discovery.

Amundsen had made the most elaborate preparations. Vast quantities of food for dogs and men, warm blankets

and thick furs, pigs, fowls, and sheep to supply fresh meat, a small library of good books, games and musical instruments, sleeping bags, tents, and sledges — all these and much more were stowed away in the *Fram*.

The King and Queen of Norway came down to the pier to see them off. Then, followed by a host of good wishes, Amundsen and his brave men sailed away. On New Year's Day they sighted their first iceberg. They crossed Ross Sea, named for Sir James Clark Ross, who discovered it. Next, they came to the great Ross Barrier, a solid wall of ice stretching across their pathway for five hundred miles. Still, Amundsen knew that somewhere along this mighty challenge of the ice king lay an opening called the Bay of Whales. Moving eastward, he found it on the following day, and there the first lap of the long journey came to an end.

When the *Fram* had been made safe to the great barrier, a camp site was chosen, and a house was quickly built from materials which Amundsen had brought with him. Cellars for the storage of food and fuel were dug in the ice. Tents and snow huts were erected for the dogs. Soon all was made comfortable, and the party was ready for the long winter which lay ahead.

Do I hear some of you exclaiming that the approaching season was not winter, but summer? Yet, you must remember that these men were in the southern hemisphere, where the seasons are just the opposite from those here. A polar expedition always winters in the ice country, and then makes its dash in the following spring and summer.

When the winter home was ready, the *Fram* sailed away to explore the waters between South America and Africa

and to return in due time to carry the explorers home after their trip to the Pole. Just before this, another ship, the *Terra Nova* bearing Captain Scott and his party, anchored at a point on the Barrier not far away. A royal welcome was given them, for the rivalry of the two expeditions was a friendly one. Each wished the honor of first reaching the Pole for their own nation, but brave and generous men never frown upon each other in the quest of great things.

Late in August, Amundsen and his men set forth, but they were soon compelled to turn back. The cold was still too great. Spring had not yet come. You know that here in the north February often seems like spring, though much winter lies ahead. And so it was there. But by the middle of October birds began to fly past and seals appeared along the shore. Then the party began its victorious dash.

Amundsen took with him four men, four sledges, fifty-two dogs and enough provisions for four months. Pressing eagerly forward, the dogs sometimes making great speed, day after day the party traveled southward. Then, the Ross Barrier was left behind and great mountains rose in the distance. At certain points they had set up mounds to guide them on their return and had left stores of supplies. In climbing the mountains, sometimes as many as twenty dogs were needed to draw a single sledge. Often, they must travel many miles to get around some wide chasm in a glacier. Great storms arose, and the wind blew fiercely. Dense fogs came to hinder their progress. In places the glaciers were so rough that skis could not be used. One day after much plodding, the sun shone out,

and Amundsen's instruments told him that he was farther south than any other explorer ever before had been.

On the night of the fifteenth of December, 1911, the men pitched their tents in great joy, for they believed the next day would see victory perch on their banner. And it did. About the middle of the afternoon, a great shout went up, for their observations told them that they were at the Pole. The flag of Norway was there unfurled, and the land about was named King Haakon VII's Plateau in honor of their sovereign.

The return trip was quickly made, and on January 25, 1912, after a journey of 1860 miles Amundsen and his men were back at the main camp, where the *Fram* was waiting to carry them home.

Before telling of Amundsen's later work, let us pay tribute to the memory of Captain Scott and his heroic comrades, whose tragic end in the cruel cold of that vast continent of ice and storm saddened the hearts of their successful rivals and cast a shadow of gloom throughout the whole world. These brave Englishmen, too, came to the Pole, but not until January 18. There, they found the records which Amundsen had left, and there they raised the British colors. On that very day, they began their homeward journey, a journey which they were not permitted to complete. Captain Scott's diary, kept under the most painful circumstances, tells the story of that last heroic march. His final entry was as follows:

"*March* 29. — Since the 21st we have had a continuous gale from W. S. W. and S. W. We had fuel to make two cups of tea apiece, and bare food for two days on the 20th.

Every day we have been ready to start for our depot 11 *miles* away, but outside the door of the tent it remains a scene of whirling drift. I do not think we can hope for any better things now. We shall stick it out to the end, but we are getting weaker, of course, and the end can not be far,

"It seems a pity, but I do not think I can write more.

R. Scott

[*Last entry*]

"For God's sake look after our people."

After the antarctic winter and the coming of spring, an exploring party found the bodies of the men in the tent where they had died. There were three of them — Captain Scott, Doctor Wilson, and Lieutenant Bowers. A fourth, Captain Oates had wandered out into the frozen wastes and died a few days before the others.

Valiant men and brave, they honored their country by hoisting its flag at the southernmost point of the earth, and in their deaths they left a priceless heritage, not only to Englishmen but to people everywhere.

Amundsen's most important later exploits had to do with arctic exploration from the air. In the spring and summer of 1925, he engaged in an airplane voyage of discovery with Lincoln Ellsworth. This first flight, costing $150,000, ended in a lead, a great open space of water between two masses of ice, in latitude 87° 44′. After landing, the ice closed up and the plane was held in its grip for twenty-five days. An area of previously unknown regions covering 120,000 square miles was explored, and soundings showed an ocean depth of 12,000 feet.

The following year, Amundsen and Ellsworth joined forces with Colonel Umberto Nobile of Italy, who had built an airship, which was christened the *Norge*. On May 11, 1926, these men set sail from Norway on what Ellsworth has described as "life's great adventure" for those who experienced it.

In two hours, the adventurers found themselves over the pack ice, in brilliant sunshine and beautiful weather. White whales were seen under the protecting shelf of some ice floe, and polar bears, frightened at the noise and sight of the big ship of the air, dove into the water of some nearby lead. The snow-capped peaks of Spitzbergen faded in the rear, and fogs occasionally hid the ice from view. Presently, the craft was hovering over the exact spot where the plane of the previous year had been ice-bound. Sixteen and one half hours had passed, and it was now May 12th. The fog cleared. There was no wind. On and on the ship sped. Suddenly, the navigator, who had been closely watching his sextant, announced, "Here we are!"

They were over the North Pole. So quickly and magic-like had it been done that it all seemed like a tale from fairyland. The ship was brought to within three hundred feet of the ice, and three flags were dropped, those of Norway, Italy, and the United States.

The ship now headed for Point Barrow, 1500 miles away. Not until 700 miles had been covered were there any signs of life. Then a polar bear came into view. As the Alaskan coast was reached, a severe storm of fog, wind and sleet was encountered. Ice coated the aerial wire. The cold froze the windmill motor which drove

the generator for the radio battery. Communication with the outside world ceased. An ice crust formed on the bow of the ship, and large pieces were thrown by the propeller against the gas bags, threatening disaster. Presently, the ship rose through the fog and cloud into bright sunshine. Diving down to within three hundred feet of the earth, nothing but ice was to be seen. "Where were they?" No one knew. Then, of a sudden, the radio began working again, and a signal was picked up from Nome, Alaska, giving their exact position. Shortly, the ship was brought to anchor at a little trading post, ninety-one miles northwest of Nome. A distance of 3393 miles over polar seas from Europe to America had been covered in seventy-two hours.

Two years later, Nobile was lost on a similar expedition in arctic regions. Although Amundsen and Nobile had quarreled in the meantime, the valiant Norwegian did not hesitate to fly to the relief of his former comrade. But, while the Italian flyer was later rescued by others, Amundsen himself was lost and no one was able to find any certain trace of him or his plane. He died as heroically as though it had been on the field of battle, and his memory will never perish.

The world can never forget the exploits of these brave men of polar explorations. And there are many others, the stories of whose lives and deeds we can not tell here.

Although vast areas of the polar regions remain to be explored, the days of the dog and sledge are undoubtedly past. We live in a new age. In future, the airplane will carry the pioneers who are to break down this old earth's last line of trenches.

Courtesy of the National Americana Society

The last conference before the Amundsen-Ellsworth flight of 1925

Keystone View Company

Mrs. Edward Stafford and Robert E. Peary, children of Admiral Peary, unveiling the beautiful Peary Monument in Arlington National Cemetery

CHAPTER V

MASTERS OF THE AIR

LET US go to those far-famed sand dunes at Kitty Hawk, North Carolina. It is December 17, 1903. The air has become cold during the previous night. A bitterly cold wind is blowing at the rate of twenty-seven miles an hour. The puddles of water are crusted with ice. Two young men and five members of a life-saving crew from a neighboring station are laying some sort of track on the slope of Kill Devil Hill. At intervals, they pause to warm their hands over a crude stove made from a large carbide can. Presently, a most curious looking device is placed on the track. It consists of two large white canvas planes, one above the other and fastened together with upright pieces of light wood and many stays. We step closer, and a light-weight gasoline motor comes to view. Underneath, skids fit the rails of the track. At the rear, we see propeller shafts, much like those of a motor-boat. Extending fore and aft are small canvas-covered planes. They seem to be controlled by rudders placed between the two big planes. The atmosphere fairly tingles with tense excitement. Clearly, something most unusual is expected to take place.

One of the two young men who are directing the operations takes his place in the plane. He lies flat, face down.

The motor is purring smoothly. The propellers hum. The big white form tugs at a stay wire, which anchors it to the track. Then, of a sudden, the pilot releases the wire. Slowly the plane starts. The stiff wind holds it back somewhat. The second young man runs alongside and holds one of the wings to help in balancing. Forty feet, the plane moves down the track.

Nothing very remarkable seems to be happening. But wait. The big "bird" is lifting itself from the track. With nothing but the air for its support, it flies free. It rises two feet from the ground, and it does not fall. A camera clicks. It rises higher — four feet, eight feet, ten feet. Forward it goes. For twelve seconds the thrill continues. Then, the machine lunges toward the ground. It touches the surface and the first free flight in history of a heavier-than-air, man-carrying plane comes to an end.

A life-guard runs three miles to the little village of Kitty Hawk, and arriving breathless, shouts, "They've done it! They've done it! Danged if they ain't flew!" History has been made above those North Carolina sand dunes on that cold, bleak December day of 1903.

I do not need to tell you that these young men were the Wright brothers of Dayton, Ohio. Orville made this first flight. A little more than 120 feet had been covered. "Not far," you say, but in the promise this flight gave of future triumphs, it might have been as many miles.

Three other flights were made on that historic day. In the last, Wilbur flew a distance of 852 feet and rose to a height of 15 feet. He was in the air 59 seconds, almost a minute, and sometimes a minute is a long while.

Unfortunately, that first plane was wrecked immedi-

ately after this great triumph. Although repaired later, the Wrights were compelled to discontinue their experiments for that autumn. As they were making ready to return to Dayton, Wilbur said, "The age of the flying machine has come at last." And indeed it had.

No blare of trumpets announced this victory on that wind-swept flying field at Kitty Hawk. No newspaper reporters were present. The Wrights did not like publicity. After three years of searching study and no end of experimenting with kites and man-carrying gliders, these brothers had flown. But they knew their success was only a beginning. They were not ready to tell the world about it. In the next two years, they made one hundred and sixty flights, averaging a mile each. In the last, they covered a distance of twenty-four miles in thirty-eight minutes. Still, the public had taken no notice of these remarkable happenings. An invention which in a quarter of a century was to revolutionize warfare and blaze new routes for transportation had not made an impression.

Then, on September 12, 1908, came the first great day in this new age of flight. At Fort Meyer, Virginia, in the presence of a little group of onlookers, Orville Wright mounted into the air. Higher and higher he rose, circling the field with all the grace of a feathered creature of the air. Once, twice, then many times, he repeated the marvelous performance. Rapt in wonder and admiration, the spectators followed the plane, riveted to the spot. One of them said, "It seemed an age since the machine started, and it appeared fixed in the sky. We were impressed that it could circle on forever, or sail like a bird over the

country." For an hour and a quarter, this practically unknown airman remained aloft, and then at will alighted as easily as a bird.

No longer could the secret be kept. Enthusiasm knew no bounds. Excited witnesses telephoned the wonderful news to Washington. Reporters telegraphed it far and wide throughout the country. It was cabled abroad. Within twenty-four hours, people everywhere were discussing this ages-old dream, come true.

At the request of the Government, a similar demonstration was made before many thousands of delighted spectators. At the same time, Wilbur Wright was thrilling the French public with amazing flights. On one occasion, he remained in the air for two hours, twenty minutes, and twenty-three seconds. The vast crowds went wild with joy. This master of the air had exceeded the farthest vision of the boldest dreamer. Some of them may have recalled the prophetic lines of Tennyson, written in 1840:

For I dipt into the future, far as human eye could see,
Saw the Vision of the world, and all the wonder that would be;
Saw the heavens fill with commerce, argosies of magic sails,
Pilots of the purple twilight, dropping down with costly bales;
Heard the heavens fill with shouting, and there rain'd a ghastly dew
From the nations' airy navies grappling in the central blue; . . .

The Wrights were honored at home and abroad as men who accomplish great things deserve to be. The question as to who had conquered the air was no longer a matter of dispute.

I do not need to tell you of the early years of these inventors. Most of you have probably read that their father

was a minister and that one evening he brought home a toy airplane. This fascinated them and they began to experiment. First they tried kites of every description. This was during the bicycle craze which swept the country during the closing years of the last century. I well remember that picturesque time. People, young and old, rode bicycles then with as much enthusiasm as they drive automobiles now. The Wrights opened a bicycle repair shop and became skillful mechanics. Without knowing it they were training themselves for the great adventure of their lives. At length, they began to read of the gliding experiments abroad and determined to master the problem of flight. Soon, gliding became their sport and pastime. Lying for hours, hidden from sight, they watched the flight of birds. Rejecting all earlier rules, first-hand, they determined the laws of flying. Each autumn found them at Kitty Hawk, but progress was slow, and often they were discouraged and almost baffled. Still, their faith never wavered, and the time came when they felt themselves masters of the art of gliding. Their thought, then, turned toward the building of a power-driven machine. Their skill as mechanics enabled them to make the motor in their own shop. You know the rest.

I want you to know before we leave these birdmen that they received the utmost encouragement from their sister, Katherine. Had it not been for her inspiration they might have failed in their great attempt. She was a school teacher and also helped to supply them with funds. The only reward she sought was the joy which came from their success. The world little knows the debt it owes to this

far-visioned woman who had even greater faith in the future of the flying machine than did her gifted brothers.

A Pioneer

Of course, we must not imagine that flying began with the Wrights. For centuries, men had dreamed of imitating the birds. Leonardo da Vinci, a many-sided genius of the Italian Renaissance, had designed models of winged planes in the fifteenth century. Many following him had done a great deal of experimenting. Indeed, it was the death of the German Otto Lilienthal by a fall from his glider that determined the Wrights to enter upon their great quest.

But I want to tell you just a little about another great pioneer. His name was Professor Samuel P. Langley, for many years Secretary of the Smithsonian Institution in Washington. Today we have a flying field named for him.

Langley was one of America's great scientists. Although a famous astronomer, he devoted all his spare time to studying the art of flying. He tried to discover the ways of the wind and its effects on surfaces of different shapes and sizes. Week after week and month after month he worked until one day he had completed a beautiful, steam-driven model. The engine developed one and a half horsepower, and weighed only twenty-six ounces. Even today this engine is a marvel. The length of the plane was sixteen feet and the spread of the wings twelve. This was America's first heavier-than-air machine, but it was not a man-carrying machine. One bright

May morning in 1896, Langley gave his model a trial. To his delight, it rose in the face of a strong wind to a height of one hundred feet and covered a distance of three-quarters of a mile. It came to rest only when its steam was exhausted and then glided to the earth as gracefully as a bird.

Time and again, Langley repeated this performance. Then, he began to think of a real man-carrying airplane. Congress appropriated $50,000 with which to build it. In September 1903, three months before the Wrights flew at Kitty Hawk, the machine was ready. The day of trial had arrived.

Langley had built his track for launching on the top of a house-boat anchored in the Potomac River. Much publicity had been given to the event, and for days newspaper men had been camped along the river. Langley's assistant and pilot, C. H. Manly, seated himself in the plane. The engine was started. Down the track the big machine started. People held their breath, tense with excitement. The success of a $50,000 experiment hung in the balance. To many, Langley's reputation was also at stake.

Just as the machine reached the end of the track, a wing post struck something. Instead of rising into the air, the plane plunged downward into the water. Fortunately, it rose to the surface unharmed, and with it the pilot. Another attempt was made three months later, but this time a second post caught, and the machine again plunged into the water. The money was now gone, and newspapers were ridiculing Langley and declaring that flight was impossible. Bitterly disappointed and humiliated,

this apparent failure hastened the death of America's great pioneer.

But the failure to fly was no fault of the machine. Langley had built it correctly. The trouble was in the launching device. To prove this, Glenn H. Curtiss years afterward flew with this same machine over Lake Keuka, at Hammondsport, N. Y.

While no one would wish to take from the honor due to the Wrights, our country can never forget the debt it owes to Professor Langley.

I have just mentioned Glenn H. Curtiss. He is another of the early fliers in this country. A quarter of a century ago, Curtiss was a young bicycle mechanic and an expert motorcycle rider. Then he turned to building light gasoline motors. In 1909, he installed an 8-cylinder engine in an airplane of his own construction and with it won the speed contest in the International Aviation meet at Rheims. In the following spring, he flew from Albany to New York in two hours and fifty-four minutes, making an average speed of fifty miles an hour with only one stop. Since then he has been a builder of airplanes and one of the foremost figures in aviation.

A Hero of the Air

One morning in 1900, a lad of twelve years stopped by his mother's chair. Presently, as she looked up from her sewing, he said, "I'm going to the Philippines." In his hand he held a letter from a friend of the family, who

occupied a government position in the Islands. It was an invitation to the lad to visit him.

The boy's enthusiastic determination swept aside the fears of his mother. She put him on a train and wired a friend in San Francisco to meet him. There, he was transferred to a ship, and on schedule time he arrived safely. Still, it was more than a month before word could get back to the anxious mother that all was well.

He came home by way of the Suez Canal and the Atlantic. Thus, he encircled the globe, and he was only twelve years old!

Who was this lad? Some of you have already guessed. Not Colonel Lindbergh. He was not born until two years later. There is only one choice left. I do not need to tell you that this boy was Dick Byrd, later to be known as Commander Richard E. Byrd, and now as Admiral Byrd.

Twelve years later, Dick Byrd graduated from the Naval Academy at Annapolis. In December of his last year at the Academy, he met with a serious accident in the gymnasium. In an athletic stunt in an exhibition, he fell from a great height, crushing his foot, the same foot which he had broken in playing football against Princeton.

For a time, he managed to hold his position as an officer in the Navy. But his bad foot and ankle interfered with his duties. Promotion was out of the question. Finally, he was retired on three-quarters pay and ordered home. This was a crushing blow. His career seemed ended—his future dark.

Then came the Great War. Even a man with a game foot might be of use in the hour of his country's need.

For a time, Byrd held a clerkship in the Navy Department at Washington. But this was not his idea of serving his country. He longed for action. Worry over his apparent uselessness brought him to the edge of a physical breakdown. The doctors ordered him to take leave from duty.

But Byrd had an idea that he could fly. That seemed to be his only escape from a life of inactivity. The desire to fly was in his blood. It captured his imagination. He begged the naval surgeons who examined him to give him a chance. And they did. He asked for a single month to show what he could do. His request was granted.

In the fall of 1917, six months after our country had entered the war, he was ordered to a flying field at Pensacola, Florida, for instruction. There, in the bright sunshine of the South, Byrd had his first experience in the air. I wonder how many of you have ever been up in an airplane? Flight is much more common now than it was then. Those were the heroic days in gaining the mastery of the air. Airplanes were clumsy, inefficient affairs as compared with the machines of today. The ways of the air, too, were more of a mystery than they are now. Scarcely a day passed at Pensacola without the occurrence of some tragedy. Byrd himself had narrow escapes. That flying field, as he said, lay "on the thin edge of eternity."

Before we go further, let me say that Byrd came from an old Virginia family. For many years, his father was district attorney for Winchester, made famous by Sheridan's ride in the Civil War. His education was obtained

at the Virginia Military Institute, the University of Virginia and, as we have seen, at Annapolis.

Byrd has two brothers. The three are frequently called Tom, Dick, and Harry. Tom studied law, but, after serving in France, turned to agriculture. His apple ranches in the Shenandoah Valley have made him rich. Harry became Governor of his state. Surely, this is an American family of which we may all be proud.

The month at Pensacola grew into six. In the spring of 1918, Byrd obtained his "Wings." He was an accepted Naval Pilot. Still, he had seen no service. But gradually a new idea thrust itself into his mind. Of course he had come to believe tremendously in the future of aviation, in both war and peace. His big idea was this: a successful airplane flight to Europe would do more to end the war and to make flying popular than anything else that could happen. It was a bold idea, born of the enthusiasm of young manhood and the conscious ability to do big things. From it, Byrd was not to escape until he had fulfilled his dream.

Of course, Byrd could not undertake this alone. He must have the assistance of the Government. Immediately, he applied to the Navy Department and received its approval. His project seemed to be on the flood-tide of success when he was suddenly ordered to Halifax, Nova Scotia, to establish a U. S. Naval Station there. Bitterly disappointed, like a good soldier, he obeyed. Then came a ray of hope. It seemed that this station was being planned as a take-off for the great ocean flight. Maybe he would have his wish after all.

Eagerly, he made his preparations. No detail escaped

him. He charted his course. He selected his companion pilot and obtained fuel, food, clothing, and instruments. Then came the Armistice, and the plan was off. Byrd did not know that another disappointment was lurking just around the corner.

In the following spring, the Navy again began plans for a transatlantic flight. But with them came the order that no officer who had seen service on foreign soil should be allowed to take part in it. This disqualified Byrd, for Nova Scotia was considered foreign soil. Of that historic flight, I do not need to say much. You know that in May 1919 Lieutenant-Commander Albert C. Read, with a crew of four, flew the naval seaplane, NC–4, from Newfoundland to the Azores, and thence to Portugal, Spain and England. This was the first transatlantic flight in history, a flight for which Byrd had paved the way.

In passing, let us note that on June 14 of this same year two brave Englishmen made the *first non-stop* crossing of the Atlantic. You see, the NC–4 stopped at the Azores, short of Europe proper. But Captain John Alcock, a young English war-pilot, and Lieutenant Arthur W. Brown, in fog, sleet and rain, flew from Newfoundland to Ireland in sixteen hours and twelve minutes. Once, when Alcock swooped down near to the water to get his bearings, he found himself flying almost on his back, and he did not know it until he saw the water. Because of a faulty engine, Harry G. Hawker and Lieutenant-Commander H. Grieve, two other Englishmen, had failed to get across but were picked up by a steamship.

Disappointment seemed to dog the footsteps of Byrd. More than anything else, he wished to fly the Atlantic.

Courtesy of the General Electric Company

A triumph of aviation — the *Saratoga,* an airplane carrier

Orville Wright
An early Wright airplane

In 1921, his chance seemed to have come. The ZR–2, a dirigible, was being built in England for the American Navy. She was to make a non-stop flight across the ocean to the United States. Byrd asked the Navy Department for permission to join the crew, and it was granted. With much joy, he sailed for England, arriving in London in August, of that year. But he reached the air station at Howden too late. Every berth was taken, and no one wished to resign in his favor.

Without knowing it, this was a wonderful stroke of good fortune. It saved his life, for the next day on a trial flight the huge airship blew up over the Humber River, and all but five on board lost their lives.

By special act of Congress, Byrd was now promoted to Lieutenant-Commander. Soon his brain was in a whirl with the idea of an arctic air expedition. He joined forces with Captain Bob Bartlett, who had been on the Peary expeditions, and Donald B. MacMillan, an arctic explorer of whom I am sure you have all heard.

In June, 1925, the party set sail and arrived at Etah in North Greenland on August first. The perils and hardships of that summer were terrific, but Byrd and his flying companion, Floyd Bennett, an aviator whose death we still mourn, did much flying. And what a sight it was to fly over rugged scenery of such grandeur — the vast expanse of ice, deep fiords, lofty mountain ranges, and glacier-filled valleys! At times, Byrd says there was "a sense of great loneliness," and the scene was sometimes "weird, mysterious and desolate." The cold, even in summer, was intense. October found the party back in New York harbor.

Byrd now planned a private expedition to the North Pole. Flying in the Arctic had captured his imagination, and to reach the Pole would be a triumph. Eagerly, he went about his plans. The United States Shipping Board loaned him the steamer *Chantier*. Thousands volunteered for the great adventure, and from them Byrd selected his crew. By private subscription, he raised about $100,000 to pay the expenses. At length, all was ready, and on April 5, 1926, the good ship sailed.

In three weeks and three days, they reached King's Bay, Spitzbergen. Then their difficulties began. Getting the airplane to land across an ice-choked harbor was an heroic task. More than once, disaster seemed certain. Next, the plane had to be tugged nearly a mile to the landing field. The big skis for the plane were soon broken in the rough snow. The men worked eighteen hours a day, but no one complained. Failure was not to be thought of. At any cost, the plane must reach the field, and it did.

Then came the first take-off. It ended in a snow drift with a broken ski and a bent landing gear. Repairs were made, and the plane got into the air. The trial flight was a great success. But when Byrd and his flying companion, Floyd Bennett, attempted their first take-off for the Pole, the load proved too great. The plane was all but upset. Although these two flyers had had little sleep for thirty-six hours, a little before midnight on this day they succeeded in getting into the air for their great flight. This was May 8th.

They climbed to 2,000 feet and within an hour crossed the edge of the great polar ice pack. Ahead, the sea of ice gleamed in the rays of the midnight sun. Behind, lay

the coast and the snow-covered mountains inland. There were no landmarks to guide these intrepid voyagers of the air — only the heavenly bodies and Byrd's instruments. A forced landing on the broken ice would mean disaster. But on they sped at the rate of nearly 100 miles an hour. To their right, lay the cruel path over which Nansen had sought to reach the Pole. To the left, was Peary's famous trail. They could see for fifty miles in every direction, and not a trace of land or a sign of life. Everywhere, bleak, frozen wastes of snow and ice.

Quickly, the hours passed, and each one brought them nearer to their goal. Fortune favored them. The sun never failed. Had clouds darkened its face, their position would have been unknown. They could not have told when they reached the Pole. But reach it, they did. At 9.02 A.M., May 9, 1926, Byrd's instruments told him that they were there. For the first time in history, the North Pole had been reached by airplane.

Byrd and Bennett circled the Pole, making a non-stop flight around the world in a very few minutes. There was no north, east or west. Every direction was south.

At 9.15 A.M., they turned back toward Spitzbergen. What motors they had! Not a one skipped a beat. Functioning as perfectly as the heart action of a healthy animal, they drove the giant plane onward, now at more than 100 miles an hour. Their deafening roar prevented speech and helped to produce drowsiness. Each took turns at the wheel, and each dozed off occasionally, overpowered by sleepiness.

In a few hours, they were back at Spitzbergen, where a royal welcome waited them. Among the first to greet

them were Amundsen and Ellsworth, who a little later were also to reach the Pole.

Arrived in New York, these heroes of the frozen wastes received a welcome such as only the great metropolis knows how to give. Congress promoted Byrd to the rank of Commander and presented him with the Congressional Medal of Honor. Bennett also received a gold medal.

Still, that great triumph of crossing the Atlantic was in the future. Byrd would never be satisfied until he had accomplished it. But it costs a great deal of money to make such a flight. Fortunately, Byrd enlisted the financial assistance of Rodman Wanamaker. He provided the money to build the *America,* the big three-engined plane for the New York to Paris flight.

The long-sought prize was now almost within his grasp, but near-disaster was waiting close by. In its trial flight, the *America* was wrecked and Bennett was so badly crippled that there was no hope of his continuing with the great adventure. Furthermore, this mishap so delayed plans that Lindbergh and Chamberlain got the start and made their crossings first.

The *America* was rebuilt. Every precaution was taken. No provision necessary for success was omitted. A waterproof radio was to keep them in communication with passing steamers. Three weeks' food supply and an abundance of water, oil, and gasoline were laid in. And there were flares and searchlights, navigating instruments and much more.

Early on the morning of June 29, 1927, the big plane got off to a rather bad start and took the air. Shortly, they

Keystone View Company

Admiral Byrd and Floyd Bennett, who first conquered the North Pole from the air

Keystone View Company

Lindbergh, shortly before he took off for Paris in the *Spirit of St. Louis*

had climbed to 3,000 feet and at a speed of 100 miles an hour were plunging onward through fog, clouds, and rain. At last, Byrd was on his way. A dream of ten years was coming to pass.

Northward along the coast and thence east toward Paris, the course lay. And what a course it was! Rain, sleet, cold, perpetual fog, frequently lost in storm clouds, and so dark that one could not see his hand before his face. Flying at an altitude of nearly two miles to gain the help of favoring winds, no water was visible. The heavens were obscured. Only the navigating instruments kept them on their course. Added to all this, the gasoline supply showed signs of giving out before land was reached. Surely, this was a situation to try the strongest nerves.

Whether the winds were with them or not, they could not tell. If not, they believed there was little hope of reaching land. At length, they picked up two ships by radio and determined their position. They were on their scheduled course. They now headed straight for Finisterre, France. Presently, Noville, one of Byrd's three flying companions, reported enough gasoline to "fly to Rome." The earlier estimate had been wrong. This gave new hope.

They were now nearing their destination. Radio signals came thick and fast. All Europe was waiting to receive them. They passed over Brest and headed for Paris. Soon a lighthouse below showed that they were off their course. They were still on the coast of France. Again, they headed for Paris. Undoubtedly, they reached it, but fog and darkness made a landing impossible without dan-

ger to themselves and the people below. They returned to the coast and landed close to the beach.

For forty-two hours, those motors had made 1500 revolutions a minute and had never missed a stroke. It had been a marvelous performance, both of men and mechanism.

All France came out to welcome Byrd and his brave companions. Paris, again wild with joy, gave them a riotous reception. Byrd's return to America was a triumphal home-coming. He is the only man in the history of our country to have made two such returns. New York's welcome was even more enthusiastic than on his return from the Pole. Such conquests of Nature appeal to the human heart. Men cannot resist them.

One might now suppose that there was nothing left for Byrd to conquer. But not so. There remained what he calls "the last challenge," Antarctica, or the South Polar Area. As I write, he has just completed his first summer there and has gone into winter quarters. Most of you have read of his exploits in those distant fields of ice and snow. Before this reaches you, it will all be a part of history, and glorious history it will be too.

Since writing this rapidly changing account of Byrd's achievements, he has won his biggest triumph. Early on the morning of November 29, 1929, just at the beginning of his second summer in the Antarctic, *The New York Times* received from him, aboard the airplane *Floyd Bennett,* a radio message, telling that he and his comrades were over the South Pole. For the first time, this far-away outpost of an unconquered and little known continent had been reached by the air. And fitting it was that his air-

plane should have been named for his brave comrade of that earlier flight to the North Pole. Indeed, Byrd's companions said that it seemed as though the spirit of Bennett were flying with them.

Immediately upon receipt of the great news, President Hoover dispatched through *The New York Times* the following message:

Commander Richard E. Byrd
Little America:

I know that I speak for the American people when I express their universal pleasure at your successful flight over the South Pole. We are proud of your courage and your leadership. We are glad of proof that the spirit of great adventure still lives. Our thoughts of appreciation include also your companions in the flight and your colleagues, whose careful and devoted preparation have contributed to your great success.

Herbert Hoover

And what a flight it was! Climbing nearly twelve thousand feet over lofty mountain ranges; ignorant of the lay of the land and the best route to choose; being compelled to lighten the load by throwing overboard a month and a half's supply of food, knowing that certain starvation faced them, should mishap befall their plane; clearing mountain peaks by only a few hundred feet; allowing for the uncertain factor of drift; wondering if the gasoline would give out; watching the conquered mountain ranges sink from view beneath the receding horizon; catching no

glimpse of anything, save the limitless expanse of ice-covered plateau, barren, desolate, and cruel; and always the intense cold and utter loneliness of it all. Surely, the heroes of the frozen wastes did not all live in the past.

And just think of it — a journey of 1,560 miles from the starting-point to the South Pole and back in 18 hours and 59 minutes! It took Peary 153 days to make his way back over the ice to the northernmost telegraph station, from which to send a message telling the civilized world that he had discovered the North Pole. But times have changed. And what trusty servants those airplane motors were! Three thousand miles of continuous throbbing with never a pause to rest. Airplanes, too: do you realize that one of the brothers who made those historic flights at Kitty Hawk was then living? Yes, and the radio. In the very moment of their triumph, when Byrd and his companions were hovering over the Pole, they were able to flash the news of victory to an eager and expectant world. At 10.29 in the evening of that memorable day, the message was received in New York, and forty-five minutes later *The New York Times* was on the street with the story. On the following morning, too, people everywhere were able to read at their breakfast tables detailed accounts of the record of heroism. Surely, this was as much a triumph for modern science as it was for the brave men who undertook this great adventure.

And Byrd's expedition (still in progress as I write) is increasing largely our knowledge of the antarctic regions. It is studying the storm centers and weather conditions, the rocks and minerals of the frozen South and its living forms. The airplane explorations are giving much wider

views of mountains and plateaus. An important object of study is the magnetic influences down there, close to the South Magnetic Pole, for you must know that the earth is a huge magnet. Disturbances in its magnetic field frequently interfere with the operation of your loud-speaker, affect telegraph lines, and make the compass needle act queerly.

So long as men of the type of Admiral Richard E. Byrd are among us, admiration for the heroic will not die.

"The Lone Eagle"

It is Saturday morning, June 11, 1927, and we are in Washington. The sky is clear, and the sun is hot. Crowds are gathering along Pennsylvania Avenue. Special policemen are on duty. Streets are being roped off. The hum of airplane motors reaches us from aloft. All Washington is astir, and thousands of visitors are within its gates. They have come from every state in the Union and from foreign countries. The very atmosphere seems to be aquiver with suppressed excitement. Clearly, something extraordinary is about to happen. Our capital city is preparing to celebrate some great event.

Following the lead of hundreds, we move toward the Navy Yard. It is early yet. But every roof top, every window, every vantage point is occupied. A great mass of humanity, eager, expectant, tense with stilled emotions, waits in the hot sun. Thousands line the Potomac. The high and the low, people from every walk of life, mingle in the crowds. Newspaper men and camera men are there. Scores of motor boats and yachts dot the surface

of the river. Patiently, the vast throng waits. No one seems to mind the time.

Presently, a ship moves out of the distance. It is the cruiser *Memphis*. Above it the giant airship *Los Angeles* maneuvers back and forth. Scores of aircraft dart hither and yon through the heavy clouds of vapor which hang over the water. Factory whistles and automobile horns blow. Church bells ring. Fire sirens screech. People shout themselves hoarse. The volcanic enthusiasm of the multitude breaks forth. Pandemonium reigns. The President's salute of 21 guns booms forth and is returned by the cruiser. And all the while the noise grows. What does it mean?

It is almost noon when the *Memphis* comes alongside the dock at the Navy Yard. A gangplank is lifted to her rail. We look about. A distinguished group is waiting. We see among them members of the cabinet, high officers of the Army and Navy, the chief of the Navy air forces, and important citizens, including Charles Evans Hughes and Commander Byrd.

We look toward the ship. Admiral Burrage is coming down the gangplank. As he reaches the waiting company, he gives his arm to a lady and they return to the ship. The momentary hush which has fallen upon the awed multitude disappears in a new burst of cheering. But many weep. They scarcely know why. Their hearts are touched with a great emotion. Something grips them as seldom happens in this busy world.

Waiting for the lady who has come up the gangplank is a superb specimen of young American manhood. They greet each other and mother and son quickly enter a cabin

of the *Memphis* to be alone for a few minutes. In respectful silence, the multitude waits, hundreds struggling with emotions which they cannot hide. A radio announcer breaks down and sobs like a child. Something is happening in the hearts of that vast throng which cannot be described and can never be forgotten.

I do not need to tell you that you have witnessed the home-coming of Charles A. Lindbergh.

It hardly seems necessary to say much about Lindbergh. His name is a household word. He has become the idol of thousands of boys, and girls everywhere look upon him with respectful admiration. In him the nation seems to have found its ideal of young American manhood. He is what every father and mother would wish their son to be. Clean, brave, modest, honest, with a simple, childlike manner, Lindbergh in those eventful days and weeks following his great achievement won the hearts of the world as probably no one else has ever done. It seemed as though men and women everywhere had been hungry and waiting for just such a splendid example of unaffected simplicity and nobility of character. And when he appeared, they honored him in an overwhelming outburst of spontaneous joy and enthusiasm. They seemed to feel that at last the hero of their dreams had come to earth.

Now, lest some of you do not know all about Lindbergh, I am going to tell you something of those years which led up to his great adventure.

Lindbergh's father was born in Sweden, and his grandfather had been a member of the Swedish Parliament and Secretary to the King. When his son was still an infant, the grandfather emigrated to America and settled in Min-

nesota. This was in 1860, just as our Civil War was beginning and when that part of the country was still wild. The first home of the family in the new land was a log cabin. Schools were few, and Lindbergh's father spent much of his time in fishing and hunting. I imagine many of you often think you would like to live in such a country. Still, he prepared for college and studied law, beginning practice at Little Falls, Minnesota.

The ancestors of Lindbergh's mother were of English, Irish and French blood. She was born in Detroit and graduated from the University of Michigan, from which his father also obtained his law degree.

In 1906, when Lindbergh was four years old, his father was elected to Congress. After that the family never lived more than a few months in one place. He tells us that he traveled much in our own country and made one trip to Panama. Of course, this travel was a part of his education, but he never enjoyed the privilege of attending a full year in any one school.

Still, Lindbergh managed to complete his high school course and entered the College of Engineering at the University of Wisconsin. He was an expert with the gun, and soon made a place for himself on the rifle teams of the University.

At the beginning of his first summer vacation, he mounted his motorcycle and with forty-eight dollars in his pocket started for Florida. He was gone six weeks but returned with nine dollars and a motorcycle that would still run.

When he was ten years old, Lindbergh saw his first airplane. This was in Washington, while his father was

a member of Congress. That airplane captured his imagination and from the fascination of that sight he has never gotten away. Probably he had no idea at that time that he would become a flier, and for ten years he did not even have an opportunity to go up in an airplane. But as the tedious weeks of the second year at the University passed, the idea of flying as a career began to take shape in his mind. The Great War had shown the future of aviation. By the middle of the year he had made up his mind to study aeronautics, or the science of flying.

Accordingly, in March 1922, when he was just past twenty, Lindbergh left the University and started on his motorcycle for Lincoln, Nebraska. He had already enrolled as a student with the Nebraska Aircraft Corporation. Before he had gone far the muddy roads compelled him to ship his motorcycle by rail and take passage on a train himself.

At the end of a month, Lindbergh's instructor announced that he was ready to take a plane up alone, or to " solo," as it is called. But this was not permitted because he could not guarantee the company against damage to the plane in case of accident.

About this time, the plane in which he had been training was sold to a man who intended using it for a " barnstorming " trip in southeastern Nebraska. Lindbergh was allowed to accompany him as mechanic. Barnstorming means flying about the country taking passengers up for so much apiece. This was thrilling sport for Lindbergh and good experience, for he had now fully determined to become an aviator. During the summer these excursions took him as far west as Montana. When he

tried to return to Lincoln in a leaky boat, paddling his way down the rivers, the undertaking proved to be too much. He was again compelled to board a train.

The following year, Lindbergh went to Florida, where he bought an old army plane, a "Jenny" as it was called. With this he made his first flight alone. It was a wonderful experience, as you can well imagine. But it was entirely successful, and in a few days he started for Minnesota by way of Texas. He paid his way by barnstorming. At one place, where he was forced to make a landing, his profits were more than $250. With a negro passenger, he looped the loop and did a number of hair-raising stunts, much to the delight of the onlookers and the terror of the negro.

Interesting as these experiences were, Lindbergh soon realized that they would never make him a professional aviator. Someone suggested that he take the examinations for entrance to the Army Air Service Training Schools at Brooks and Kelly Fields, Texas. He did so and on March 15, 1924, became a Flying Cadet at Brooks Field. Although of 104 cadets who entered only 18 succeeded in graduating from Kelly, Lindbergh's early experience and real love of flying gave him an advantage which brought success. Within a year he had received his "pilot's wings" and a commission as second lieutenant in the Air Service Reserve Corps.

His next important experience was as an air mail pilot between Chicago and St. Louis. Here he had many thrilling adventures, on two occasions being compelled to abandon his plane and save his life by dropping in a parachute.

One night in the autumn of 1926 while he was flying the mail, it came into his mind that he might win the $25,000 prize offered by Raymond Orteig for a non-stop flight between New York and Paris. Of course this would require a plane of his own, and he had no money with which to build it. Fortunately, he found public-spirited men in St. Louis who were willing to supply the funds.

The plane, the famous *Spirit of St. Louis,* was built in San Diego, California, and on April 28, 1927, Lindbergh gave it the first trial flight. As you may well guess, it exceeded expectations. Ten days later, he took off for St. Louis, flying by night over the snow-capped mountain ranges and the plains beyond. From there he flew to New York, arriving at Curtiss Field, Long Island, late on the afternoon of May 13th.

He waited several days for favorable weather conditions. Then, on the evening of the 19th just as he was preparing to attend a theater performance, a report from the Weather Bureau announced a high pressure area over the North Atlantic. You who study physical geography know that this means clearing skies and absence of rain. Immediately, Lindbergh went to Curtiss Field, where his plane, which he had christened *We*, was serviced for the great adventure.

He had hoped to get a few hours of sleep, but this was impossible. Just before daybreak a light rain began to fall, but this stopped with the rising sun. The plane was towed to Roosevelt Field adjoining Curtiss, and just before eight o'clock on the morning of May 20th Lindbergh was off for Paris.

What boy or girl has not thrilled time and again at

thought of that lone flight? Here was a gallant youth of matchless courage, flying through fog, rain, and sleet and pitting his endurance and skill against the desolate wastes of the North Atlantic. Despite the report of the Weather Bureau, the skies were far from clear. Once when sleet started to collect on the plane he was compelled to turn back and go around the clouds. For some of the way the temperature hovered around zero. In mid-ocean, trees, beautiful landscapes, and green islands seemed to be painted against the horizon. These deceptive sights were due to the mirages, so frequent on sea and desert.

Through it all, Lindbergh directed his course by compass, and by means of indicators allowed for wind drift with amazing accuracy. He was headed for Ireland, and he hit it at almost the calculated spot. He passed on to Southern England and thence across the Channel to France. The sun went down as he left Cherbourg behind, but the beacons along the Paris-London airway guided his flight. A little before ten o'clock the lights of Paris gleamed through the darkness, and a few minutes later he was circling the Eiffel Tower at a height of 3000 feet above its summit.

The lights of Le Bourget Field appeared below. Lindbergh says, "I flew low over the field once, then circled around into the wind and landed."

The famous non-stop flight to Paris was a matter of history, but the wonder of it had only begun. Thousands waited on that field of honor. Their enthusiasm knew no bounds. Madly they rushed toward the plane. No power could hold them back. Lindbergh started to climb out of the cockpit, where for many

Using the Gyro-compass

(*Above*) The Coolidge cathode ray tube invented by Dr. W. D. Coolidge, assistant director in Dr. Whitney's laboratories

(*Below*) Dr. W. R. Whitney in his laboratory listening to electrons

hours he had been cooped in quarters so cramped that he could hardly move hand or foot. The crowd seized him and for half an hour he was carried on the shoulders of a wildly cheering mass of seething humanity. Then through a resourceful trick the crowd was led aside, and Lindbergh escaped to the American Embassy.

It is impossible to describe the scenes that followed in Paris, Brussels, and London. No other American, and probably no one else in all history, has ever aroused the world to such an overflowing outburst of spontaneous enthusiasm. It was not simply because Lindbergh had done something that no one else had ever done. It was a tribute to the man himself — to the dauntless courage, the unaffected modesty and simple majesty of this new knight of the air and exemplar of American ideals. Had Lindbergh been an ordinary hero, a man of lesser calibre, he would have been fêted and honored, but he would not have thrilled the world.

It would take another chapter to tell of the presents he received, the telegrams and prodigious quantities of mail that came, and the offers mounting into millions bidding for his services.

With scarcely a second thought, Lindbergh cast aside these offers. One was for $750,000 from a motion picture house. Another offered him $240,000 for forty minutes of his time. He was to stand before a moving picture camera and read *The New York Times* account of his flight. But he answered, "I am an aviator; not a movie star."

Lindbergh had consecrated his life to aviation, and nothing could swerve him from his purpose.

Now let us return to Washington. It is still that memorable June day of 1927. He and his mother emerge from the ship which has brought him from France, a naval ship sent especially by the President for this purpose. They take their places in the automobile at the head of the official party. The parade moves toward the center of the city. Bands play. The waiting thousands along the route cheer again and again. Soldiers and marines and mounted cavalrymen lead the way. Onward the procession moves to the natural amphitheatre about the Washington Monument. Lindbergh mounts the stand and President Coolidge grasps his hand. About them stand high officials of the Government, the ambassadors of foreign countries and members of the diplomatic corps with their wives and daughters. The President moves to the front of the platform and when the applause has ceased begins to speak. As he concludes his address of praise and welcome, he bestows upon this hero of two continents the Distinguished Flying Cross.

As he repeatedly did in France, Belgium, and England, Lindbergh responds with a brief but dignified speech, which captures every heart.

He is entertained at the White House as the guest of President and Mrs. Coolidge. In the evening he attends a meeting of the National Press Club, where he receives the tribute of representatives of the press and Government. On Sunday he visits Arlington and lays a wreath on the grave of the Unknown Soldier. At a meeting in honor of the 150th anniversary of the American flag, he receives the Cross of Honor, presented by Charles Evans Hughes.

On Monday Lindbergh flies to New York, where he

receives an ovation exceeding, if that were possible, his reception in Washington. Four days later he hops off for St. Louis. Eager throngs impatiently await his coming, and again he receives the plaudits of the multitude and the honors of the city.

Lindbergh has now become a national idol, popularly known as *The Lone Eagle*. On several occasions he has served as an ambassador of good-will to other nations, and he is an official advisor to our air forces. But most of all he is the hero and ideal of American youth. The nation has honored itself in honoring him.

I should like to tell you of other daring aviators and in particular of Sir George Hubert Wilkins and his explorations in the Arctic and Antarctic, but it would take a book. With the flights of Lindbergh, Byrd, and Chamberlain and of the brave men who conquered the Pacific, aviation entered upon its great triumphs. You young readers of this book will live to see the highways of the air as much a common-place as those of the land beneath.

CHAPTER VI

KNIGHTS OF INVENTION

YOU KNOW much about the great inventors of the past. I want to tell you now of a group of inventive giants about whom you probably know little. All but one of them (1930) are living and still at work.

These men are not inventors as we think of the inventors of earlier years. They are of a new kind. They work in a different way. They are really highly trained scientists. We might call them research men. But they are this and more. They make discoveries in the laboratory and then apply these discoveries in practical machines and devices. They are surrounded with all that science and money can provide in the way of equipment and facilities. Often they have trained assistants.

The lone inventor, working in his garret, is a picturesque figure of a day that has gone. Men now-a-days co-operate in splendid team work. Inventions are frequently the product of many minds. And yet over them all sits a master genius. We might think of him as a major-general of scientific research. As a general directs his troops and keeps the attack constantly moving toward a common end, he guides the work. Some of these men about whom I shall tell you began as lone workers and later passed on to the larger field. But they are all knights of the new way of making the world move.

A Youthful Inventor

I SAY a youthful inventor, and yet the youth I have in mind has reached three-score years and ten. But he is still a youth in spirit, keen, alert, active as a man of forty, and a modern knight of invention whose work is known throughout the world. His name is Elmer A. Sperry.

Were you to go to New York and pass over to the Brooklyn end of the Manhattan Bridge, you would find a large building known as the Sperry Building. In an office on the eleventh floor sits this director of many enterprises. He is the most active and enthusiastic one of a large staff of engineers and trained subordinates. His knowledge of every detail of the numerous projects upon which his men are working is marvelous. No one knows more than he about any particular device. The next step is always clearly in mind. He never falters. His plan of action is ready for execution.

But I must tell you something of the youth who began to invent and was the owner of a factory in Chicago before he was twenty-one. First you wish to know that he was born at Cortland, N. Y., in 1860. His mother died shortly after, and he was cared for by his father and relatives. However, his was not a boyhood of poverty and hardship. From his mother, who was a woman of education, having excelled in the sciences and mathematics, young Sperry undoubtedly received his bent for invention. We are told that the textbooks and notes which she left became an inspiration to him.

Some of you may know that at Cortland, N. Y., is a state normal school, and it was there that Sperry received

his early education. Even then the subjects which interested him most were the sciences and anything having to do with machinery. Engines and locomotives fascinated him. He was sixteen when the Centennial Exposition came to Philadelphia, in 1876. It was his good fortune to be able to attend. There he saw the big Corliss engine and was even permitted to help in starting it. This visit to the great exposition made him dream dreams of one day becoming an inventor himself. He little knew how soon this day would come.

In his shop at home he had always been given to building water-wheels and windmills. Once he built a tricycle to run on the railroad tracks. At fourteen he invented a locomotive headlight by which an engineer might see around a curve. He did not know that one of his most important inventions in after years was to be a searchlight of great power.

Sperry's boyhood home was not far from Cornell University. Even before he had finished at the normal school, he had made the acquaintance of the professors of physics and engineering. When nineteen he entered the University. He had already invented an improved electric arc lamp and a dynamo. He seemed to be a born inventor. In fact, Mr. Sperry says, "The ability to invent is something that I feel is born in one. I am not sure that it can be acquired." Anyway the fascination for invention was too strong for young Sperry to resist. He left college at the end of a year.

Going first to Syracuse, he worked to improve his lamp and dynamo, building larger and better ones. So interested did men become in his inventions that capital was

offered with which to continue them. His enterprise was a success from the very start. At twenty he found himself in Chicago, the proprietor of a factory known as the Sperry Electric Company. In it he manufactured dynamos, motors, lamps, and electrical devices. From that day to this he has never ceased to be an inventor and manufacturer, but chiefly an inventor, although he prefers to be called a research worker.

We often think of an inventor as hampered by poverty and lacking the means, or facilities, with which to do his work efficiently and well. This has never been the case with Mr. Sperry. His inventions have always provided him with abundant funds for all he wished to do. In this he has been like George Westinghouse, another boy inventor who became one of the greatest engineers of his time.

As you can readily see Mr. Sperry has been a self-made man. Through his own efforts, he became an engineer, one of the leading engineers of our country. His knowledge of chemistry, physics, electricity, and engineering is wide and thorough. But he began when not nearly so much was known regarding these subjects as men know today. When he was a boy, engineering as we think of it now was just beginning. He has grown up with the profession and has even kept ahead of the procession. By this I wish to say that there is not so large an opportunity for a young man to become a successful inventor in these times without college training as there was when young Sperry began to dream of building mechanical devices.

But let me say that a practical genius who adds to his natural ability scientific training has wonderful oppor-

tunities. Never get the idea that all the inventions have been made. I once heard Dr. Willis R. Whitney, of whom I have told you elsewhere, say that we have not yet scratched the surface of scientific discovery and invention. I should like to be able to come back here a hundred years from now. I am sure I should not recognize this old world as it will be then.

Of course, there is not a boy or girl reader of this book who has not played with a spinning top. And older folks often play with it too. Many of you have seen the gyroscope vendor, who sits at a crowded street corner or at some vantage point of a fair or show, making his uncanny gyros perform all sorts of tricks and stunts. A gyroscope is simply a spinning top in another form. The hoop which you roll along the street stands upright and does not fall for the same reason that a top spins on a point. Your bicycle operates on the same principle. So, too, does the earth in its rotation on its axis. The earth is a spinning top gone "to sleep." Should it cease to spin, it would wobble about much as a top does in dying down.

But why have I begun to talk about spinning tops? Well, for the reason that Mr. Sperry has put the top to work. He has used its principle in one of his most important inventions. The gyroscope compass, used now on most battleships and large liners, grew out of his study of how and why a top works. This compass is far more accurate than the ordinary magnetic compass. And it points to the true north and not to the magnetic north. No matter how the ship may move on the high seas or be tossed by the waves, the axis of this gyro-compass, which rotates at a very high speed, will always point in the same

direction as the axis of the earth. That is, toward the pole star. No other invention of recent times has done more for navigation than has the Sperry gyro-compass.

In the laboratories at the Sperry building, I have stood beside this compass and seen it operate. There, it is placed under the influence of motions, more violent and disturbing than any met with on the seas, but it never fails to indicate the true north. "Metal Mike," as Mr. Sperry calls this mechanism, is more sensitive in many ways than a human being. It "feels" the motion of the earth about an axis 4000 miles away, and instantly adjusts itself to any other movement, however slight.

And so, too, with the gyro-stabilizer for keeping a ship on an even keel. No matter how rough the sea or high the waves, this little giant prevents all tossing and pitching. Decks remain level. There is no groaning of strained timbers. The ship simply rises and falls on the waves, moving forward as though the sea were still.

Without knowing it many of you have benefited from one of Mr. Sperry's more recent inventions. It is a new arc lamp for projecting moving pictures on the screen, a light more brilliant even than the sun. Just at the beginning of the World War, officials of the United States Navy came to Mr. Sperry to ask that he invent a searchlight for use in gun practice. Thirty years before, Mr. Sperry had erected on the shore of Lake Michigan at Chicago the tallest and brightest beacon light in the world. He now returned to those researches of his young manhood.

The solution of the problem was simply a matter of experiment. Most of you know that the ordinary arc

lamp produces its light by striking an arc, as we say, between two pencils, or rods, of carbon. It was in this way that Davy produced the first electric light in history with a battery of two thousand cells. The temperature obtained in such an arc is about 3700 degrees Centigrade. Mr. Sperry saw that, to get a more intense light, he must change in some way the composition of the carbon rod. He added the rare element cerium to it, of course, after much experimenting. This increased the candlepower from seven to eight times.

Occasionally you see in the evening a powerful beam of light playing over the clouds. In all probability this is a Sperry searchlight. Some of these searchlights develop a billion candlepower. A temperature of 5000 degrees is produced in the arc, and, were it not for the curvature of the earth, its beam of light might be seen for a thousand miles. This light is brighter than sunlight as we receive it at the earth's surface. An aviator found that at a distance of twenty miles from one of these searchlights he could read a newspaper as easily as by the light of the sun at noonday. Even at fifty miles the type was still clear.

These searchlights are used by many navies. Every airport has one. They help to guide the air mail. They were a powerful means of defense against aircraft and Zeppelins in the war. And now they are making possible the projection of moving pictures so that everyone, even in the largest audience, may see with ease.

I have not even hinted at the most of Mr. Sperry's inventions. He has taken out more than 400 patents covering many devices. He has done much to improve the Diesel engine, widely used on ships and now becoming

important for aircraft. Recently he invented a device for automatically making known in a moving train flaws in railroad rails. There seems to be no limit to his ingenuity. His brain is as tireless and full of energy as the long-sought perpetual motion machine.

Many honors have come to Mr. Sperry. He has been awarded the John Fritz Medal, and he is a member of the National Research Council. But he feels that his real reward is in the "thrill of the work itself," which is his very life.

A Scientist, Turned Inventor

BEFORE me lies a slab of a highly polished, beautiful material, resembling in appearance the amber of the ancients. It has a multitude of forms and a host of uses. Just now it is coming of age, for it was twenty-one years ago that the inventor of this new product announced his triumph. I do not think I shall be far wrong in saying that every boy or girl who reads this book will be able to find close at hand at least a half dozen articles molded from this material. In all probability your umbrella handle, the body of your fountain pen, the buttons on your coat, your phonograph records, the dials of your radio set, the handle of your knife, beads if you have any, the distributor head of your automobile motor and a dozen other parts of the car, besides much more about the home are fashioned from this new substance, totally different from anything of a similar kind found in Nature. If I tell you that its chemical name is "oxybenzylmethylenglycolanhydride," this will mean no more than a collection of Egyptian hiero-

glyphics. But, if I say it is Bakelite, then you know just what I mean and a lot about it.

From the title of this sketch you know that the man who invented this artificial material with a thousand uses was first a scientist. In fact until he was past middle life, he did not dream of ever being anything else than a scientist. He was born abroad, in the Flemish city of Ghent in 1863, and did not come to this country until he was thirty-six. But his great achievements have been made here, and we are proud to call him an American, as indeed he is by adoption and citizenship. L. H. Baekeland is his name, and he lives at Yonkers, New York, and Miami, Florida. His offices are in New York City, and his industrial plant and research laboratories are in Bloomfield, New Jersey.

Baekeland was educated in the schools and university of the ancient city of his birth. Science subjects and chemistry in particular were his favorite studies. Upon graduation from the University he became an instructor in a normal school and later associate professor in the university from which he had graduated. At about this time he won a gold medal and a scholarship which permitted him to study at universities in a number of European countries and also to visit America. As it proved, this was to become his home. He was offered a position as chemist with a New York firm, which manufactured photographic supplies, and he wrote back to Belgium that he would not return to his position at the university in Ghent.

Already Baekeland was becoming an expert on the chemistry of photography. Before he took up the search that led to Bakelite he had made a fortune through the

invention of Velox printing papers. Scores of you young readers have used these photographic papers without ever giving a thought as to the man who might be their inventor. For the first time he invented a paper which was sensitive to artificial light. Before, sunlight had always been used in printing. Although Baekeland's invention was much better than anything else in use, he had great difficulty in getting photographers to adopt it. They preferred the old way. People seldom like change. But he started a company in Yonkers to manufacture and sell Velox paper, for he had confidence that it must win. In this he was right, and he was soon able to sell out to the Eastman Kodak Company for a figure that made him moderately wealthy.

This was when automobiles were still new, but Baekeland had already become an enthusiastic motorist. He was also fond of motor-boating. With wealth in his possession, he might easily have devoted himself to these two fascinating pastimes. Instead, he chose to begin the biggest task of his life and something which, although he did not know it, was to make him famous as well as a much wealthier man than he then was. Fortunately, he was not compelled to work in poverty.

Back of his home in Yonkers he built a laboratory, and there he worked all day and far into the night for week after week and month after month. Years passed before success came, but that is the price a research worker must usually pay for a great invention. Although those days were often discouraging and trying, Baekeland says they were the happiest of his life.

Now let me tell you what he sought to do. His purpose

was to prepare an artificial resin. Of course the word *resin* does not mean much to you. But you are acquainted with rosin, shellac, asphalt used in roofing and road building, and various waxes. These are natural resins. What Baekeland wanted to do was to make an artificial resin which would be much better than anything found in Nature. I presume the fact that chemists had worked on this problem for thirty years and more without success may have challenged his interest. To attempt the "impossible" always has a wonderful fascination.

The work of other chemists had seemed to show that such a resin might be made by combining two chemical compounds known as phenol and formaldehyde. Phenol is ordinary carbolic acid, and formaldehyde is a common disinfectant and a preservative of biological specimens.

But in spite of all Baekeland's skill and ingenuity the products which he obtained were queer and totally different in properties from what he wanted. Night after night he went to bed baffled, but never defeated. Many would have given up; not Baekeland. Again and again he returned to the attack.

He added chemicals of various kinds, but the stuff was stubborn. It would not behave as he wanted it to do. It was as obstinate and exasperating as some youngsters. One day the way the sticky mess in his kettle was frothing and foaming led Baekeland to think of using pressure and a higher temperature. The battle was over. He obtained from his kettle a product which hardened to a solid like amber, transparent, clear and beautiful. It was hard, of remarkable strength, and was unaffected by all ordinary solvents.

It became an ideal insulator for electric purposes. It is used in making bullet-proof airplane propellers, gears for machinery which are noiseless, switchboards, and a multitude of other things. We are now told that the furniture of the future may be made of Bakelite.

A large research staff under Baekeland's direction at his plant in Bloomfield are at work improving the product and finding new uses.

This Belgian chemist who sought fame and fortune in a new land and found both has received many honors. Offices, medals, and honorary degrees have been bestowed upon him. In his later years he is giving more time to the recreations he loves, but he is a knight of invention still.

Something New in Glass

I WANT to tell you just a little about a man who has scored a great triumph for American chemistry and invention. In doing so he has produced something new in glass.

Glass-making is one of the oldest of the arts. Long before the beginning of history men were skilled in it. Glass is found in the ancient tombs of the Pharaohs. The Phœnicians, those early masters of trade, carried glass with them in their journeyings. Glass is mentioned in the Bible. The Romans and, later, the artisans of Venice were skilled in its manufacture. In more recent times the blowing of glass centered in a number of European countries, particularly in Germany. Before the World War all the glass used in chemical laboratories came from Germany. The famous Jena glass was then standard the

world over. But it no longer is. An American chemist has produced something better.

The name of this chemist is Dr. E. C. Sullivan. He was born in Elgin, Illinois, nearly sixty years ago and received his early education in a Chicago high school. There he gained his first interest in chemistry. His instructor, too, told him of the fortunes he believed could be made in industrial chemistry. This decided young Sullivan on the choice of a career. He went to the University of Michigan to study chemistry and in due time was graduated. A year or two after, like so many chemists of that day, he went abroad to study. In 1899 he received his doctor's degree from the University of Leipzig and returned to this country to become a teacher at Ann Arbor.

While I think of it, let me say that it is no longer necessary to go abroad to study chemistry. Just as good instruction can be obtained now in American colleges and universities. America is now one of the leading chemical nations of the world.

But let us get back to Sullivan and what he did. Pretty soon he left Michigan to become a chemist for the United States Geological Survey. There he got just the kind of preparation necessary for a glass chemist. Then came his opportunity. He was made chief chemist of the Corning Glass Works.

If any of you have home laboratories, I venture to say that the chemical glassware in them is marked "Pyrex." If you are not certain, look and see. This is the thing that Sullivan and his assistants did. They produced Pyrex glass, now famous throughout the world.

They began with an attempt to make a glass for a

trainman's signal lantern which would stand all kinds of weather without breaking. You know that a milk bottle suddenly heated sometimes breaks. This was much more often true twenty years ago than it is now. That was before Pyrex had been invented. This breakage, as any of you who study General Science know, is due to the rapid and unequal expansion of the glass with heat. The glass does not heat evenly. One part expands, grows bigger, before another. This strains the glass, and it breaks.

But suppose we had a glass which did not expand any, or only a little with heat. Then there would be no strain, and the glass would not break. That was what Sullivan started out to produce. And he succeeded. But he did a great deal more than he expected to do. He got a glass which, not only would not break easily with change of temperature, but one that was strong. It would stand dropping or being struck fairly hard blows. Besides it proved to be affected by chemical substances the least of any glassware known. Here was a wonderful array of properties.

After much experimenting and some persuasion, Sullivan succeeded in getting his new ware used in the kitchen for bake dishes. Now it is a strong competitor for this purpose. Indeed it was first thought that this would be its greatest use.

Then came the World War, and American laboratories were cut off from German glass. One day a chemistry professor from an Eastern university called upon Dr. Sullivan to know if he would not undertake the making of chemical glassware. But the outlook was not very encouraging. It did not look as though the sales of this

kind of glass would be very large. Still, the demand continued. At length the Government became interested, and the work began. Today, Pyrex chemical glassware is standard everywhere. It is used in Europe as well as in America. We no longer import glass of this kind. Nothing else has ever been produced equal to it. This triumph marks a proud moment in the history of American chemical achievements.

And not only is this new glass used in the laboratory; chemical industries use it in a score of ways. Miles of glass tubing are made from it and thousands of tanks and retorts. Besides it forms the best sort of glass insulators for electrical work. Radio insulators of Pyrex served Admiral Byrd on his trips to both poles. It is better for telescope mirrors than any other glass made and is surpassed only by what the chemist calls fused quartz.

Thus the boy who had his imagination fired in a high school laboratory has become one of our country's great chemists and inventors. He is still at work, directing the research of his organization. Other inventions are likely to come from his laboratories.

A Boy Who Wanted to Be a Chemist

Last week I heard a man who stands in the forefront of American chemists address a gathering of scientists. Not only this, he is known in Europe as well as in America. More than forty years ago, together with a partner named Griffin, he opened a little two-by-four laboratory as a consulting chemist in Boston. He now occupies a palatial three-story building on the banks of the Charles River in

Cambridge, Massachusetts, and his clients are to be found in every part of the world. The pay roll for the staff of engineers and trained scientists whom he employs to assist him in his work amounts to a thousand dollars a day.

This man is Dr. Arthur D. Little, born in Boston in 1863. He came from an old New England family on his father's side. His father, too, was an artillery officer in the Civil War. As a lad Little's parents moved to Portland, Maine, and it was there that he first attended school.

On his way from school one day, when he was a dozen years old, another boy invited him to his home. There for the first time Little saw a chemical laboratory. His friend had some apparatus and chemicals for doing simple experiments. To the astonishment and delight of Little, the two boys made the gas hydrogen by pouring dilute sulfuric acid upon pieces of zinc, just as many of you have done. And just as has happened with you, too, the generator blew up, but fortunately without injuring either of them. This was great fun for Little, and he decided then and there to become a chemist. He never changed his mind, and he has never been sorry for his decision.

But I think I hear some of you saying, " A chemist is not an inventor." Yes, a chemist may be a most important inventor. We have inventors of all sorts these days. To be an inventor it is not necessary that a man build some new kind of machine or make a device that overnight turns some old-time process upside down. For instance, Dr. Little has made himself one of the world's greatest experts on the chemistry and manufacture of paper. In his plant in Cambridge, too, he does things on a big scale. He has recently worked out a process for manu-

facturing newsprint paper from Southern woods. This has never before been possible. Large portions of our forests each year go for wood pulp, the stuff from which paper is made. To print the Sunday edition of *The New York Times* requires 750 tons of paper. Then, think of all the other papers in the country, besides the multitude of other uses for paper. Our forests can not stand this demand always. Just think of how important it is to have a chemist like Dr. Little, who can invent a process which will enable us to make use of a whole new supply of wood for this great necessity of industry. Such work is invention of a most valuable kind.

Now we must go back to Little, the boy we left playing with chemicals in the home laboratory of his schoolmate. He went home that night in great excitement and announced to his father that he was going to be a chemist. From that day he began to experiment on his own account. With a concave mirror he devised a crude sort of telescope and studied the stars. And he experimented with chemicals. He seemed to like explosions best. I never knew a boy yet who did not. Fortunately, he never came to grief in this way, but it is a dangerous pastime.

In high school Little was not a brilliant student except in chemistry. In this he shone and became assistant to the chemistry teacher. At a school in New York he prepared for the Massachusetts Institute of Technology, often called "Tech." In three years he left to take a position as a chemist in a paper mill. After two years of this he set up as a consulting chemist, as already mentioned.

Those were strenuous days. Chemists were not looked upon with much favor then. Fees were small and the

Courtesy of the American Telephone and Telegraph Company

President Hoover, then Secretary of Commerce, participating in the historic demonstration of television, April 1927

A glimpse of the Holland Tunnel in the process of construction

income meager. In the first year the two partners made only $600 more than their expenses. The big things in chemistry which we know today had not begun. Without knowing it, Little was to have a big part in starting them.

After seven years Little and Griffin were on their feet, but in that year Griffin was killed by a terrible explosion in the laboratory. Grief-stricken and handicapped, Little had to go on alone. This he did, prospering more and more as the years passed and coming to be known throughout the world as a great chemical engineer. In 1917 he built the big laboratory building where he tries out processes and invents new ones. There, many a crippled industry he and his assistant chemists and engineers have rebuilt and made to prosper.

One day a visitor to Little's laboratories remarked, " You can not make a silk purse out of a sow's ear." Just to show that " impossible " things can often be accomplished these days, Dr. Little accepted the challenge. From materials taken from a sow's ear he made artificial silk, and, if you were to go to the museum in his building, there you would find the silk purse on exhibition.

Many of you must have seen and possibly some of you have used the special mulching paper put between rows of growing plants to hold the moisture and keep down the weeds. This was originally employed on the sugar plantations of the Hawaiian Islands. It was in the Little laboratories that this paper was developed from the waste products of sugar mills. A host of processes have been discovered in that hive of industry and ingenuity. Dr. Little has done much in new ways of using fuels and in improvements for paper manufacture.

Together with Mr. George Eastman, of Kodak fame, Dr. Little has established at the Massachusetts Institute of Technology a new and different kind of engineering school, in which a student gets instruction and industrial practice at the same time. Dr. Little, too, is a most interesting and popular speaker on scientific subjects. He believes that all progress in industry and civilization depends upon this work of research — adding to our knowledge of Nature's ways and her forces.

Probably no other American chemist has received more honors at the hands of his brother chemists, both at home and abroad, than has Dr. Little. And he is still an active figure in this field of his boyhood ambitions.

A Master of Space

Let me tell you something now of an inventor who stands between "two worlds." As a lad scarcely out of his teens, he began. He was then like the old-time inventor in his garret. He worked alone and unaided. It is all the more to his credit that he did. The triumph which he won belongs to him alone. Before the great scientists in their laboratories had grasped the vast possibilities of wireless waves, a youth of Italian and Irish parentage fairly took their breath away with a startling success. You now know that I mean Guglielmo Marconi, the inventor of the wireless telegraph.

But success came so rapidly to this youthful inventor that he soon ceased to be a lone worker. The financial backing which came enabled him to establish a pioneer research laboratory and to surround himself with assist-

ants. But he was always the director. He led in the work. His were the discoveries which brought to the world this new mastery of space.

You may wonder why I tell you of Marconi in a book about great Americans. But he has been much in America, and several of his early triumphs were here. So frequently has he visited us that he almost seems to be an American citizen. We can not afford to leave out one whose discoveries led to the radio art, which gives us all so much pleasure.

When I think of Marconi, a whole picture gallery comes to my mind. I see him as a lad twelve years old on his father's estate at Villa Griffone, Italy, eagerly questioning his instructor, Professor Righi, about the newly discovered Hertzian waves. With his master, he repeats all the experiments of which he can learn. Then he waits. Surely, he thinks, some of the great scientists in their splendidly equipped laboratories will be quick to see how these waves can be used for signalling through space. Every day he looks for an announcement of some invention putting them to work. But only disappointment is his reward.

Again, I see him as a student, perfecting himself in the study of the sciences and of music. Yes, and he is still waiting for some wireless invention. But to the scientists these ether waves which the brilliant German physicist, Heinrich Hertz, has discovered are only a curiosity. True, this discovery has shed a wonderful new light on the ways of Nature. It has made clear a number of perplexing puzzles. But, with the telegraph and the infant telephone, of what use would wireless telegraphy be anyway? Even

so great a scientist as Sir Oliver Lodge can not see the importance of it.

Then, another picture comes. I see Marconi, driven to action by what seems the inexcusable delay of the learned men of science, sending signals over short distances on his father's estate. Already he has improved on the methods of Hertz. Without knowing that he is making a master stroke, he grounds one terminal of his sending coil. The other he connects with a plate of tin raised on a pole. On the opposite side of the garden, he erects a similar pole and connects the plate of tin to his crude receiver. Pretty soon he has made use of the coherer and decoherer in his receiving set, instruments long since cast aside but of vital importance to Marconi's success. He improves both and increases the height of his aerials. He is now sending over distances of several miles. Still, the world knows nothing of these remarkable happenings.

Now I am with him in England. It is the year 1896, and Marconi is twenty-two years old. He has set up his instruments in the Post Office building in London. Sir William Preece stands by my side eagerly looking on. Thick walls prove no obstacle to the passage of these mysterious waves. Marconi scores a brilliant success. He signals between two land stations miles apart with equal ease. From the Isle of Wight to the mainland his messages flash. I go aboard a yacht upon which this youth, more English in manner than Italian, has installed his apparatus. We are at the yacht races of the Kingstown regatta, ten miles from shore. Marconi reports the results for a Dublin paper. A little later I see him communicate be-

tween Queen Victoria and her son, the Prince of Wales, who is ill on his yacht off the English coast.

I pass over a whole series of triumphs, which make him wireless master of half of Europe, and find myself aboard Marconi's yacht off Sandy Hook in October, 1899. This is his first appearance in America. He is reporting the International Yacht Races for the New York *Herald*. He now holds patents on his inventions, and a company has been organized with a capital of a half million dollars to put the business of wireless on the commercial map. Stock worth $300,000 has been given to Marconi, and $75,000 have been set aside for his work of invention and further research. The boy who dared to dream of conquering space with wireless waves is now a capitalist and a pioneer explorer of the unknown.

I cross the Atlantic with this first of radio enthusiasts and return with him early in December of 1901 to Newfoundland. I see the fierce winds of that bleak coast tear loose from their moorings his huge kite aerials and sweep them out to sea. But he never falters. He knows no such word as failure. He hardly dares to hope for the success of his great experiment, but he will not abandon it. Then from the foot of Cabot Tower on Signal Hill, I see him and his assistants manage, in the teeth of a fierce gale, to get a kite 400 feet into the air and hold it. Sitting beside him and Mr. Kemp in an upper room of an old barracks, we listen to the roar of the surf three hundred feet below. Marconi is holding the receiver to his ear. He has been listening for half an hour. Still, no signal. He passes the instrument to his companion. Presently, there comes the tap, tap, tap of the

decoherer. But, no sound. Yes, there it comes — the three dots of the letter " S." Mr. Kemp passes the instrument to Marconi. Tense with excitement, he listens. There can be no mistake. Transatlantic wireless has passed into history. From the powerful station at Poldhu on the coast of Cornwall, England, signals have been sent from continent to continent.

Thus did Marconi pass quickly and surely from those simple experiments in an Italian garden to a great success.

Marconi's next step was to adopt the principle of tuning, discovered by Sir Oliver Lodge. He applied this in practical apparatus so as to make possible the receiving of waves of a certain length and no others. Everyone knows what this means now; the radio would be impossible without it. Thirty years ago this discovery was little short of a miracle. It was Marconi's knowledge of music which enabled him to make use of this principle in a working device. For instance, he knew, as most of you do, that a vibrating string producing a certain note will set a nearby string of the same pitch also into vibration. This is the fact, applying to wireless waves as well as to sound waves, which made tuning possible. But it was a long way from the knowledge of this to a practical wireless set which used it. And in those days of pioneering it was Marconi who led the way.

Thenceforward the development of wireless passed into other hands. Without Marconi, the triumph of the ether waves might have been delayed for a generation. But after he had blazed the trail, others followed in quick succession.

Professor J. A. Fleming invented what is known as the

Fleming valve. It made use of a discovery by Edison, known as the "Edison effect," to give a receiving bulb which allowed the radio currents to pass in one direction and not in the other. This was a great improvement. Then came the crystal receiver. Many of you have seen them. My first wireless experimenting was with a crystal set. Occasionally we see one now.

The invention, however, which revolutionized radio receiving was Dr. Lee de Forest's audion bulb. He converted the Fleming valve into the first real vacuum tube detector as we know it now. From that point a small army of engineers in the service of the American Telephone and Telegraph Company and of the General Electric Company have made possible the wonders of radio as we know them today.

Still, it will always be hats off to the youthful Marconi, whose vision has made it possible for us to "listen-in on the universe."

Many of the youthful readers of this book can not remember when radio was not a commonplace of the household. But within the memories of thousands, yes, of millions, now living it has traveled the pathway from its simple beginning to the glorious reality that we know today. "In One Man's Life" is the title of a book on another subject. We might say this also of Marconi and his connection with the radio art. And he has never ceased to experiment. He is still at work.

I do not want you to think that all the radio inventions have been made. We have all of us seen the coming of the talking movie. Television, that is, the transmission of pictures over a wire and also by radio, has been demon-

strated. But there are still other goals to reach. Mr. David Sarnoff, an official of the Radio Corporation of America, believes that the radio broadcasting of pictures to the general public will come. One feature of this will be radio motion pictures in the home. Sometime he believes, too, we shall have the radio transmission of pictures in their natural colors.

Never worry. When these inventions have all been made, still others will beckon to us from the future. We shall never catch up with the possibilities of scientific discovery.

Just try to picture this world as it would be without the radio. Most of all, you would probably miss the radio programs — the music, the addresses, the reports of distant football and other games, and the banishing of loneliness which this broadcasting has brought to you and to countless thousands of others. And suppose you were to be deprived of the great sport of getting distant stations, some of them a quarter of the way around the earth possibly. Of course the giving up of the radio would be a keen personal loss to each of us.

But just think of how much greater this loss would be to ships in distress at sea. We could fill a book with the thrilling accounts and deeds of heroism in the radio rescuing of ships in peril. Indeed, the first practical use of wireless was on board ships to communicate with each other and from ship to shore. Soon after his demonstrations began in England, the British Admiralty paid Marconi $100,000 for the right to use his radio inventions in the Navy. Other nations also paid him royalties.

And again, what would the farmer and fruit grower

do without the radio broadcasting of weather and crop reports? I happened to be in a fruit section of the West one spring evening when the temperature began to fall. A killing frost threatened. But the radio from the United States Weather Service spread the warning. Thousands of smudge pots were marshaled for action. The frost came, but this timely warning helped to save the fruit over a large area.

I can remember the torchlight processions and the picturesque oratory of an old-time political campaign. Such scenes and events are now only a memory. They have passed into history. The radio has banished them. The great army of voters do not need to go to mass meetings. They sit in their easy chairs and listen to the candidates over the radio. A speech which sounds good to the listeners on the benches in the lecture hall may cost a lot of votes among those in the vastly larger radio audience. The radio has become the country's most important factor in deciding the result of a national election.

No, we could not get along without the radio in our homes and in our business. Life would seem pretty dull without it. Like the shot fired at Concord, Marconi's invention of the radio started something which has been "heard round the world."

The Grand Old Man of Invention

No account of American invention could be complete without saying something about that "Grand Old Man" of invention, the most valiant knight of them all, Thomas A. Edison.

Just now, at the time I am writing, our country is celebrating the "Golden Jubilee of Light," which means the fiftieth anniversary of Edison's invention of the electric lamp. I presume some of you have specimens of the postage stamp issued by the Post Office Department in honor of this occasion.

We have just been trying to imagine what the world would be like without the radio. But if a radio-less world would seem dreary, what would it be, were we to go back to tallow candles, kerosene lamps, and open gas jets? Not even the gas mantle had been invented at the time Edison exhibited that first electric lamp. But there are many living who remember those times, and indeed much earlier and more primitive ones. My father, born in the same year with Edison and still living, was a dozen years old at the time Colonel Drake sank that first oil well at Titusville, Pa. His boyhood days were passed by the light of the open fireplace and the tallow candle.

I do not need to tell you the story of that first incandescent light. What boy or girl is there who has not read it? Before me stands an exact reproduction of the historic lamp. I see the horseshoe filament of charred cotton sewing thread, and I am carried back fifty years and more in imagination to that crude workshop at Menlo Park, New Jersey, where it was born. I see the labor of thirteen months of patient search for a suitable material for the filament. Edison, scarcely stopping for days at a time to eat or sleep, tries out substance after substance — scores of them. Scientists are ridiculing his bold idea of a small incandescent electric lamp for office, home, and shop. Each experiment seems to be a failure. Nearly

$40,000, a large portion of his capital, have been spent. Not to succeed threatens him with financial ruin. More than that, it will bring to naught the vision of a new day in the progress of his fellowmen.

But Edison has no thought of failure. He knows that somewhere the right material is awaiting him. It is simply a matter of finding it. One day he picks up a piece of cotton thread. He has tried almost everything else. Why not try this, he thinks. Immediately, he carbonizes, that is, chars it. Then he tries to mount it, but the fragile filament breaks. He repeats the process, times enough to break the heart of a man whose mind is not fired with a lofty purpose. At last he succeeds. The filament is mounted in the bulb. The air is pumped out, and the lamp sealed. I see Edison and his assistants turn on the current. The lamp glows with a wonderful brilliancy. How long will it last? That is the next question. Although these men have scarcely slept for days, they sit right there for forty hours to watch that lamp. And who would not? It is the world's first electric lamp, and they are making history.

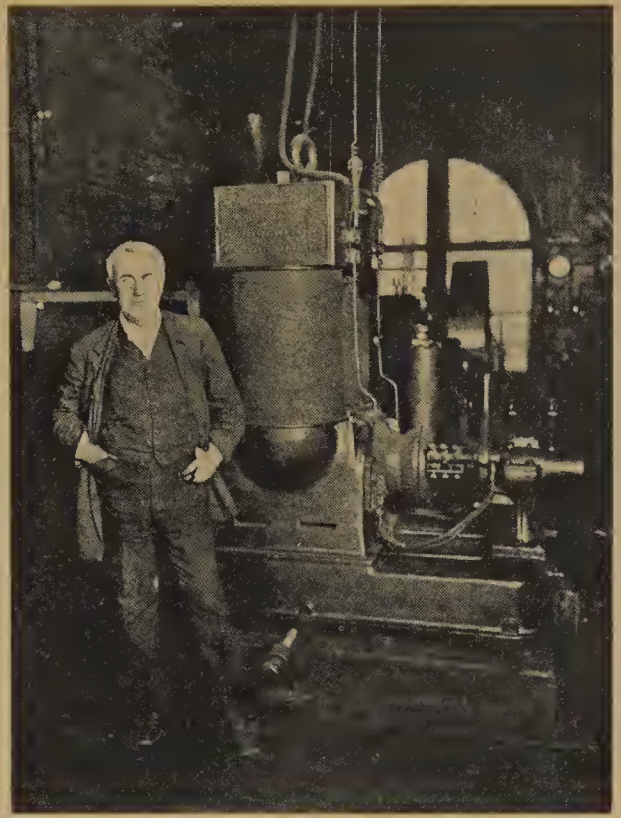
Yet, that lamp, a marvelous achievement a half century ago, served its time and has gone. Like the stage-coach and the pony express, it has given place to something better. A hundred-watt tungsten filament lamp of the present day gives seventy-six times as much light for the same cost. To return to the reddish-yellow light and low candlepower lamps of the 'eighties would seem almost like going back to the dark ages. And the cost of producing the same amount of light with them as we have now would be staggering.

Edison's first central power station on Pearl Street in lower New York supplied 400 lamps through thirteen miles of underground wires. The output was only a little more than five hundred kilowatts, and all of you who have electricity in your homes know what a kilowatt means. More than two-thirds of all the homes in the United States have electric light and power now, and the business of supplying it is capitalized at twenty-three billion dollars. A great industry has grown out of Edison's discovery, and again we may say, "in one man's life."

Edison is the last of the old-time inventors. The products of his laboratories have been the work of his hand and brain. Of course, he has had assistants, but he has been the guiding genius, and he has originated the ideas. He has never used the present method of building up a great invention from the partial discoveries of a large staff of subordinates. He has always played a lone hand. How well he has succeeded, all the world knows. The story of his life, too long to tell here even in outline, is a glorious one. Invention after invention crowds its pages, any one of which would be achievement enough in the individual lives of most of us. Just now he is trying to make our country independent of an overseas supply of rubber. And we may be perfectly sure that he has other projects in waiting.

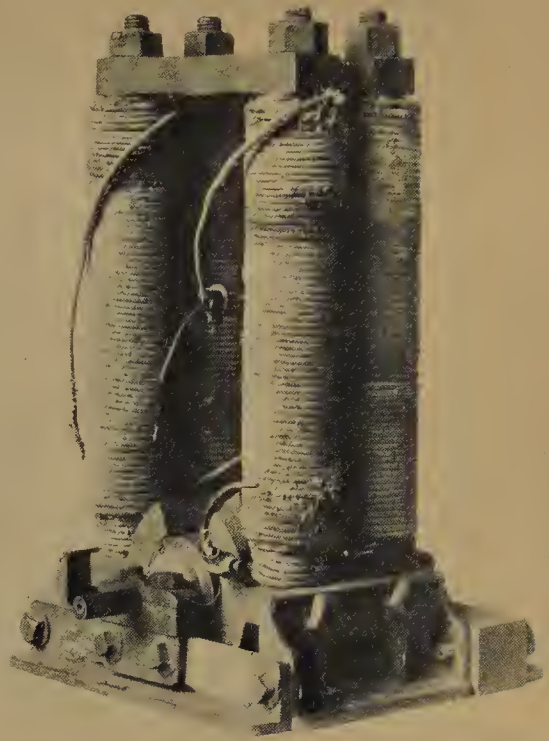
A Born Inventor

The other day I received a sample of a new alloy, that is, a combination of metals. It is called "Konel," and for



From Everyday Science, *Courtesy of the Goodhue Co.*

Thomas A. Edison and the dynamo that generated the first commercial electric light



One of Edison's first dynamos. Now on exhibition in the Smithsonian Institution at Washington

George Westinghouse at work

one thing it is to be used as a substitute for the rare and expensive metals, platinum and irridium, as the filament in high-class radio tubes. Now this metal came from the Westinghouse laboratories in Pittsburgh, and it is about the founder of those laboratories that I wish to tell you just a little.

Many of you already know that I mean George Westinghouse, and I presume some of you could tell me a number of his inventions. Before reading farther, suppose you try.

I have headed this sketch "A Born Inventor," for that is what George Westinghouse was. Even as a lad, he wanted to invent. He liked to work with tools, and, if the truth must be told, he disliked school. His father had a machine shop at Central Bridge, Schoharie County, New York, where George was born in 1846. While he was still a small boy, the shop and family home were moved to Schenectady, New York. There, the youthful inventor grew up.

A boy with a bent for invention could have no better opportunity than young Westinghouse enjoyed, although his father looked upon all his boyish inventions as mere "trumpery" and gave him no encouragement. But at length a kindly workman fitted up a room in the attic of the shop, where he could invent to his heart's content. There, he built a small steam engine, with which he ran a boat on the Erie Canal.

You will be interested, too, in another achievement of the lad. One day his father was going away to be gone for a week, and he called him to the shop, showing him a pile of pipe which he wished to be cut into pieces of a

certain length. That upset young Westinghouse's plans completely, for he had his heart set on a good vacation. But his ingenuity was equal to the occasion. His father was scarcely out of sight when he rigged up an automatic device which he connected to an engine and to his great joy succeeded in cutting the pipe in a very short time. Strange as it may seem, even this exhibition of inventive ability did not open the father's eyes. He could not see where the boy's real future lay.

When the Civil War came in 1861, although only fifteen, like many another lad, Westinghouse wanted to enlist. Of course, his father would not give permission, so one morning he and a companion made their way to the railroad station and boarded a train bound for the front. But, much to the dismay of the would-be soldiers, the elder Westinghouse discovered what was up and arrived at the station just in time to foil the rash adventure. Two years later, however, he did enlist, entering the Navy, where he rose to the rank of Acting Third Assistant Engineer.

Still less than twenty when the war closed, Westinghouse entered Union College, located in his home town. But, like Elmer Sperry of the gyroscope inventions, he preferred actual work in a shop to class-room instruction. Dead languages and mathematics bored him, and soon he convinced the president of Union and his father that college was not the place for him. Nevertheless, in after years he keenly regretted this unwise decision.

Fired with the spirit of invention, he joyfully returned to the bench and the lathe. Soon, too, he was turning his natural ability to account. His first opportunity came as

the result of a railroad accident. One day while he was returning from Albany, the two rear cars of the train ahead jumped the track. Always interested in mechanical things, Westinghouse walked forward to watch the work of putting the cars back on the rails. It proved to be a painfully slow job. For two hours with crowbars and blocking, the train crew laboriously pried and pushed until the wheels were again in position. But while the men had been working Westinghouse had been thinking. Such tedious exertion and delay seemed entirely useless to him. When he took his seat in his own train for the completion of the home trip, he already had in his mind the picture of a car-replacer. It was to be a set of rails, running off at an angle like a short switch. When this device was clamped to the track at the place where a car had been derailed, the engine might easily pull the car back into place. There would be no back-breaking labor, and the time could be reduced to a few minutes.

Westinghouse could not sleep that night until he had put a drawing of his plans on paper. The next morning, he went to his father, for it would take money to make his dream of a practical invention come true. In the first place, he must obtain a patent. Then he would need funds to manufacture his device. The father, however, placed no faith in the idea and would not assist. Disappointed but not baffled, he laid his scheme before several influential men of the town. To his delight, he found two who had enough confidence in him to advance five thousand dollars to try the thing out. As a result, before he was twenty-one he had become a successful

manufacturer, and his invention was in use on many railroads.

This sounds much like a tale from fairyland, but it is all true, and even larger success was soon to follow. His next opportunity also came with a railroad accident, and a more serious one than the earlier mishap had been. This time, Westinghouse was traveling from Schenectady to Troy, when his train unexpectedly came to a standstill. Again, he went forward to discover what the trouble might be. Two battered freight locomotives told the story of a head-on collision.

Westinghouse began to think, "Why did this accident happen?" By questioning, he learned that, although the track had been straight for a long distance so that the engineers could see each other plainly enough, there was not time to stop. The brakes would not act quickly enough. You must remember that this accident occurred when railroads were yet young. Each car carried a brake, which had to be set by hand. I well remember those picturesque days. Long before a freight train would reach the station at which it was to stop, brakemen could be seen coming from the little house on the top of the caboose and distributing themselves at intervals over the tops of the cars. How their jackets did flutter as they made their way through the stiff breeze kicked up by the moving train! Then, with might and main they set the old "armstrong" brakes. Grinding and squeaking, those primitive brakes slowly brought the train to a halt. But the process could not be speeded up. Emergencies could not be met. Often an accident could not be avoided.

Most young men would have said, "Too bad, but it

could not be helped." Not so with Westinghouse. He felt sure that a remedy could be found. Immediately, pictures began to pass through his mind of some sort of brake device that might be operated by the engineer and set with great force. The idea of a steam brake suggested itself but was cast aside. Steam would condense in the connecting pipes beneath the cars, and in winter the pipes would freeze. Still, somewhere the ideal power for his purpose existed. Of that, he was certain. It was simply a matter of finding it, and to the search he began to devote every moment of his waking hours. Every other thought was crowded from his mind. He even dreamed of it at night.

One day, he chanced to see an account of the Mont Cenis Tunnel, then being bored in Switzerland. It told of the use of compressed air for operating the drills. Delighted, he threw down the magazine. At last, he had found the motive power for his brake. In that moment, he knew that success would finally come.

Westinghouse had now married and with his bride he moved to Pittsburgh, little dreaming of the big part he was to play in the future growth of the great steel center of America. He still continued the manufacture of his car-replacer, and in his spare moments he worked on a model of the air brake. Soon he had one ready for regular train operation. Then began his big battle.

In order to make his dream come true, he must stage a big demonstration to show the railroad world what his braking system would do. But railroad officials were timid. They feared that the new mechanism might wreck the train. Everywhere, Westinghouse met with disap-

pointment. Men would listen to him, but they would not loan him a train of cars and locomotive for the experiment. The risk seemed too great. It was a good deal, too, that this young man in his early twenties was asking.

Still, as the old saying goes, it is a long road that does not turn. At length, in W. W. Card of the Panhandle Railroad, he found a man willing to give the invention a trial. And a most dramatic trial it proved to be. Let us see what happened.

It was a bright spring morning of 1869, a year that many now living can remember. Westinghouse had provided the locomotive with a steam-driven pump, which compressed air to a pressure of about sixty or seventy pounds per square inch. This air was supplied to cylinders and pistons under the cars, which set the brakes, and all was controlled by a valve, close to the engineer's seat in the cab.

The train, carrying officials of the Panhandle Railroad and Westinghouse and a number of his friends, pulled out from the Pittsburgh station. Can you not almost feel the thrill of anticipation which the youthful inventor must have experienced? Surely, this day was to mark a big moment in his career. Its sun would set either upon success or failure. And the verdict was not long in coming.

Gradually, the train picked up speed until it was going thirty miles an hour. Then something happened, something not on the program. Dan Tate, the young engineer, saw a drayman blunder onto a grade crossing only a few hundred feet ahead of the locomotive. At first glance, a frightful accident seemed unavoidable, for the drayman

in whipping up his horses had been thrown sprawling across the tracks. Surely, here if ever was the opportunity to give that brake a test. Reaching for the valve handle, Tate gave it a quick turn. The rest is a matter of history. Never before had a train been stopped so quickly, nor probably so violently. Just four feet short of the unfortunate man, the train came to rest. And in less time than it takes to tell it, angry passengers, with bruised shins and battered hats, came tumbling from the cars to know why they had been given such a jolt. The scene before them told the story, and everyone present knew that the air brake was a great success.

Westinghouse's first act following the demonstration was to send a telegraph message to his father telling of his triumph. Still, he failed to receive the encouragement and financial aid for which he had hoped. But others came forward with assistance. The Pennsylvania Railroad now offered a train for a demonstration, which was as successful as the other had been, and he was permitted to use this train for other trials throughout the country. A company, of which Westinghouse became president, was organized with leading railroad men as directors. Business came rapidly, and with it wealth and prestige. In the following year, he saw his air brake introduced in England and on the Continent.

Of course, that first brake was crude and clumsy. For twenty years, Westinghouse continued to perfect it. By 1888, it was handling the longest trains with ease and safety.

In the meantime and later, Westinghouse did much else. We must remember that he was a born inventor.

He could not be happy if he were not inventing something or other. He drilled the first gas wells in Pennsylvania and introduced this cheap fuel into the industrial life of Pittsburgh. He applied compressed air in operating the "interlocking" signal system for controlling traffic in crowded centers of railroading. More important than all else, he built the first big alternating-current dynamos for producing electric power on a large scale. It was with Westinghouse dynamos that Niagara Falls were put to work in the early 'nineties of the last century. He electrified the World's Fair grounds at Chicago in 1893.

I well remember an amusing incident of that time. Every evening for a considerable period, a bright star was seen in the west shortly after sunset. Someone started the report that this was an immense electric light, invented by Edison and operated by current from Westinghouse's power plant. Not for some time was it discovered that the "electric light" was nothing other than the planet Venus, which at that time of year is in that portion of the heavens.

The most important of Westinghouse's later inventions was his compressed-air shock absorber for automobiles. One day, while sitting in the rear seat of his car, he found himself bounding against the top with great force. Surely, there must be a remedy for such an unpleasant experience, just as there had been for an imperfect braking system. His shock absorber was the answer.

In 1913, after a long illness, he died, but the work he did lives on. In a host of ways, we all benefit from it. Without his air brake, transportation systems would be sadly crippled, and his alternating-current generators

ushered in the day of big things in electricity. Westinghouse was more than an inventor. He belongs to the "empire builders" of America.

Now we must close this story of invention. Not, however, because the record is complete. Far from that. But the chapter is growing long. The record will never be complete. It will grow with the years. While it is being written new events are always occurring. I have no doubt that some of you will help to make them in the years to come.

CHAPTER VII

AMONG THE SCIENTISTS

I WONDER how many of you young readers can tell what we mean by a scientist. Undoubtedly many of you are studying Latin, for we begin Latin earlier now than they used to do when I went to school. That being the case, some of you are acquainted with the verb *scio,* meaning to know. It does not take much imagination to see that the word *scientist* comes from this Latin verb. Now I think you could guess readily enough that a scientist is one who knows. That is, he is one who has definite, accurate knowledge of much that is interesting and useful. Of course, there are many kinds of scientists. One may study and make discoveries about rocks; another about animal life; another about the stars and other heavenly bodies; while still others will unravel the secrets of chemistry, physics, and electricity.

In any case, a scientist is more or less of a discoverer. He pries into the secrets of Nature and tries to find new facts about this universe of which we are a part. Did you ever stop to think that all of human progress rests upon such discovery? Without it we should stand where the cave man stood. For instance, where should we be today, had not someone gained the mastery of fire and applied this knowledge to the smelting of ores; discovered the

expansive force of steam; or explored the mysteries of electricity and harnessed it to do the world's work? Certainly we should not be living in this age of super-science with all its comforts and advantages, each one of us having at his or her command the equivalent in power-driven machinery of fifty willing slaves.

I wish to tell you now about just a few of this country's great masters of science.

A Naturalist

We shall begin with John Burroughs, a naturalist, of whom I am sure many of you have read much. Of course, a naturalist is one who studies Nature firsthand. We are all of us naturalists more or less, but some seem to have an inborn love of the great outdoors and all living things. John Burroughs was such a man.

Probably Burroughs' early life had something to do with his love of Nature, for he was born in the country and lived on a farm. That was more than three-quarters of a century ago, a time when much of the country was still new and the pioneer battled with the wilderness. Every farm household was an independent unit. The clothes of the family were of homespun, made from the wool sheared from the flock of sheep. Boots and shoes were made at home from the hides of cattle grown on the farm. Practically all of the food was home-grown. The sugar came from the maple trees. Wood, cut in winter and seasoned in summer, supplied the fuel. Those sturdy folk needed to buy little at the village store, which was often a long way distant. Roads were poor, and they

traveled only when necessary. Their never-ending struggle in obtaining a living from the soil brought them close to Nature. To the sensitive soul of a youth like Burroughs, who loved the birds, the trees, the flowers, and the brooks, this life, despite its many hardships, brought a continual delight.

As a lad, Burroughs often drove a yoke of oxen fifty miles over almost impassable roads to Catskill on the Hudson, carrying with him tubs of butter for shipment to New York. We should now cover this distance in a couple of hours with an automobile. Then it was a matter of several days. But the trip had its rewards. It gave Burroughs an opportunity to get marvelous glimpses of the wild life, the trees, and the flowers. This was far more interesting, too, than to swing a scythe or hoe corn and potatoes in the hot sun.

Burroughs was born at Roxbury, New York, in 1837. His ancestors on both sides had come from Ireland many years before. His mother's father had fought in the Revolution and been with Washington at Valley Forge. He was one of a family of ten children, and as you may imagine hard work was a regular part of his early life.

I wonder if any of you have read *The Hoosier Schoolmaster*. If you have, you know the kind of school in which Burroughs received his first instruction. There are yet schoolhouses in many parts of the country similar to the one he attended. But the teachers are far better prepared now than they were then. In those days, the teacher often knew little more than the pupils before him. Discipline was one of his chief duties. Usually the school year lasted only during the winter months. The

same subjects, studied from the same textbooks, were repeated year after year. We wonder now that so many received in those poorly kept schools education sufficient for the big things they did in later life. The fact is that many of them were self-taught. This was true of Burroughs. It was also true of the famous millionaire, Jay Gould, who was a pupil with Burroughs in that country school at Roxbury.

Burroughs, too, became a country schoolmaster. For eight years, he moved from community to community, staying but a short time in one place and "boarding around" as was the custom in those days. This wandering life carried him as far away as Illinois. But teaching was always distasteful to him, and discipline difficult. At length, he decided to follow it no longer. He went to Washington to enlist as a soldier in the Civil War, but took a position in the Treasury Department instead.

For nine years he remained in Washington, leading a monotonous life far from the great outdoors which he loved. Still, even there he cultivated a garden, which was the delight of his free hours. Already, he had begun to write. His first essay, written while teaching at Newburgh, New York, had been accepted by *The Atlantic Monthly*. His first book, *Notes on Walt Whitman as Poet and Person,* was not a success. But in *Wake Robin,* written in 1871, he produced a charming book, which is still full of interest. To study Nature and to report his observations in delightfully written essays now became the purpose of his life.

To make a living, however, was a necessary task, and for eleven years following his Treasury service he was

a National Bank Examiner. He had already bought a small farm in the township of Esopus, New York. There, he intended some day to settle down to live close to Nature. More books followed: *Winter Sunshine, Birds and Poets, Locusts and Wild Honey,* and *Fresh Fields.*

Twice Burroughs visited Europe, once to help transfer $50,000,000 in bonds from the Treasury Department to a foreign capital and once with his family on a pleasure trip. Later, he visited Alaska and Siberia and with Roosevelt he went on a trip through the Yellowstone Park. And everywhere he wrote for others of what he saw and learned. *Camping and Tramping with Roosevelt* was the result of his Yellowstone experience. Even when he was past seventy, he made an ocean voyage to Hawaii.

I can not tell you of all the books he wrote. *My Boyhood* was one of his last as well as one of his best. In it one gains a sense of companionship with a kindly soul, who knew how to make you feel a kinship with every living thing.

In 1921, just before his eighty-fourth birthday, he died, rich in honors and in the esteem of his countrymen and first among American naturalists.

A Great Physicist

PHYSICIST is a big word. It needs explanation. Some time some of you may study in high school a textbook of physics bearing on the title page the name of Robert Andrews Millikan. Millikan is one of the world's greatest physicists. In 1923 he won the Nobel Prize in physics, awarded by the Swedish Academy of Science each year

for the most notable discoveries in this field of natural science. It is about this man and his discoveries that I wish to tell you now. But first let me say that a physicist is one who studies the physical forces of Nature and the ways in which they act. In particular, he tries to learn as much as can be known about such subjects as gravitation, energy, motion, heat, light, and electricity. These are the very foundations of Nature, and so the field of the physicist is as big as the universe itself.

Let us begin by telling how Millikan happened to receive the Nobel Prize. All of you have heard of the Nobel Prizes, and some of you know that these were established by Alfred Nobel, a Swedish chemist who made a fortune as the pioneer inventor and manufacturer of modern high explosives. Five such prizes, each consisting of about $40,000, are given each year for the most important work in certain lines of activity. Millikan's discoveries had to do with the electron, and upon this pigmy of the universe hangs another story. Let me tell you about it.

I have no doubt that many of you know something about electrons. But whether you do or not, all of you use them. It is the control of the flow of electrons from the hot filament in your radio bulb that enables you to listen in on the universe. Every time you turn on an electric light a swarm of electrons rushes along the conductor and through the tungsten filament, making the electric current and producing heat and light. In the lightning flash a veritable tornado of electrons plunges with incredible speed from cloud to cloud or from cloud to earth. If you have ever had an X-ray picture taken of your teeth or of some broken bone, you have benefited

from the discharge of electrons in a vacuum tube. The wonderful effects of radium are due largely to the hurling forth of electrons at great velocities. Electrons and their twin brothers, called protons, are the working capital of all kinds of substances. Without them, this universe would dissolve and disappear.

It is of electrons and protons that the atoms of the elements are built. All of you have studied enough chemistry to know that there are ninety-two elements, and that these elements consist of atoms. The atoms of one element are different in their properties, or qualities, from those of every other element. For instance, hydrogen and oxygen are gases, mercury is a liquid, and sulfur and gold are solids. For many years scientists believed that atoms were little, hard, indivisible particles, the smallest in existence. Now they know that electrons and protons are unimaginably smaller. An atom is something like a little solar system of these infinitesimally small particles. You know that the planets, of which our earth is one, revolve in orbits, or paths, about the sun. Well, scientists believe that the electrons of an atom revolve in a similar way at very high speeds about a central nucleus, consisting largely of protons. Each particular kind of atom, such as copper or silver, has a different number of electrons and protons from every other kind of atom. In some way this different grouping of these tiny particles for each element gives the various properties which we find for the different elements.

Now, something else about these electrons and protons. An electron is not a little hard particle of matter, but a moving charge of negative electricity. In other words it is

a tiny point of energy. Its motion gives to it all the properties belonging to what we used to call matter. A proton is a corresponding charge of positive electricity, only much smaller than the electron and about 1800 times as heavy. Now a hydrogen atom consists of a nucleus having a single proton with one electron revolving about it. As you probably know, the hydrogen atom is the lightest of all. Each heavier atom contains more protons in the nucleus with the same number of electrons revolving about it.

Although no one has ever been able to look inside an atom, and never will, the scientist knows from many experiments that there are large spaces between the moving electrons and between the electrons and the nucleus. That is, an atom is exceedingly porous. Your body, for instance, consists of atoms made up of these electrons and protons. But the great British astronomer and physicist, Eddington, tells us that if all the electrons and protons in the body of an average individual could be condensed into a solid mass, so that there would be no spaces between them, this solid mass would be just visible with a microscope. So you see that each of us is a moving vehicle of thinly disguised space. We are not much after all.

Now you have had the story of the electron; let us return to Millikan. Millikan received the Nobel Prize for measuring with the utmost accuracy the quantity of negative electricity on a single electron. "Of what use was this?" I hear you ask. So far as we can now see, this discovery has no money value. And yet it would be a rash person who would say that it never will have. But is money the only worth-while object of scientific discovery?

Our knowledge of the stars makes no fortunes and pays no dividends, but it enriches beyond any ability to describe our thoughts and lives. To know more about the mysteries and the forces of Nature is of vastly greater importance than to make a million dollars. And without such discoveries, too, there would be no millionaires. Only as man finds out these things, does he become the master of Nature and of his own life. A great discoverer like Millikan is the real leader of our progress.

Millikan is a product of the Middle West. He was born at Morrison, Illinois, in 1868. His father was a clergyman and a man of learning. From earliest childhood this future scientist was surrounded with books. He lived in an atmosphere of education. At Oberlin College he studied physics and chemistry along with other subjects, graduating in 1893. Two years later he received a doctor's degree from Columbia University and afterward studied in Germany. For many years following he taught physics, first at Oberlin and then at the University of Chicago, where he became a full professor. He is now Director of the Norman Bridge Laboratory at the California Institute of Technology.

And all the while Millikan has continued to experiment and discover new facts about Nature. We call this work research. It is really the most important work that anyone can do. All of our wonderful progress would stop, did not someone make new discoveries. Just suppose that Michael Faraday had not, about a century ago, discovered the laws governing electromagnetism and that no one else had made these discoveries. We should have no dynamos or electric motors, no great power plants and

long-distance transmission lines, while the electric lamp and the great "white ways" of our cities would hardly be dreams. But Faraday did not have the remotest idea of all that would flow from his original discovery. His only purpose was to add to our knowledge of Nature and her forces.

And so with Millikan and his discoveries. Tomorrow they may be the working capital of new industries.

I imagine that some of you have heard of what are called the *cosmic rays*. Millikan has done more to increase our knowledge of these mysterious messengers from the heavenly spaces than anyone else. They are similar to X-rays, only much more highly penetrating. Every quarter of the heavens is continually sending them forth. At first their meaning was a mystery. But Millikan has shown that this energy is probably liberated by the union of electrons and protons in the process of giving birth to new elements in the depths of space. From his work, it seems quite certain that elements are constantly being born. Our universe is a going concern. It can not be destroyed. Millikan believes that the energy radiated from the stars in prodigious quantities in the form of heat and light produces electrons and protons, and that these in turn unite to form elements. Out of this material, nebulæ, stars, and solar system are built. And somewhere along the way of such a world process come life and civilizations and you and I.

Does this seem difficult? I hope not. Some time you will learn much more about the work of this great discoverer. And we hope that he may continue his explorations of the mysteries of stars and atoms for many years

to come. Known in Europe as well as in America, Millikan is a scientist whom the whole world delights to honor.

Another Great Physicist

I PRESUME there is not a reader of this book who has not heard of the great star Betelgeuse, one of the brightest in the group of stars known as Orion, the Huntsman. The three brilliant stars in "Orion's Belt" are easily found high above the horizon on any clear winter evening. Betelgeuse is not one of these, but a star in the great rectangle which forms a part of Orion.

So far away is Betelgeuse that, like all other stars, the most powerful telescope will not magnify it beyond a point of light. Still, a way has been found to measure its diameter, which turns out to be 260,000,000 miles. This is more than three hundred times as large as our own sun. Indeed, our sun, which looks big simply because we are quite near to it, is a mere pigmy in comparison with Betelgeuse. The whole orbit of the earth with the sun at the center, measuring a distance across it of 186,000,000 miles, would fit inside Betelgeuse with a margin of many millions of miles to spare.

Why should I be talking about Betelgeuse when you think I should be telling you of a great physicist? For the reason that this great physicist discovered the way to measure the diameter of Betelgeuse. His name is Albert Abraham Michelson, the first scientist in this country to receive a Nobel Prize. This was in 1907, and the prize was awarded for important discoveries about light.

Michelson is an adopted son of the United States, having

been born in Germany in 1852. However, he did something that many boys of American birth aspire to do. He won an appointment to the Naval Academy at Annapolis, graduating at the age of twenty-one. But he did not follow a life on the sea. During his student days at Annapolis, he had shown a great liking for science and mathematics. Two years after his graduation, he was asked to go back to Annapolis as instructor in chemistry and physics. There he remained for four years, leaving for a position in the office of the *Nautical Almanac,* where his work dealt largely with astronomy. At twenty-eight he went abroad for two years to study in foreign universities, returning to take a position, first at the Case School of Applied Science, then at Clark University, and finally in the University of Chicago. Since 1892, long before most of you were born, he has been head of the department of physics there.

Now that we have the outline of his life, let us see why Michelson is called a "great physicist." We have noted that he received the Nobel Prize in physics for work on the subject of light. While still a young man at Annapolis, he became much interested in the velocity, or speed, of light and determined to measure it more accurately than anyone else had ever been able to do. Of course it had been known for many years that light travels with the incredible velocity of about 186,000 miles a second, said by Einstein to be the greatest possible velocity to obtain anywhere in the universe. But "about" was not accurate enough for Michelson. He wanted to know the precise velocity. By an ingenious use of mirrors for the reflection of light over a measured distance and back, he

has placed this number at 186,360 miles per second, the most accurate measurement ever made.

For the purpose of making other discoveries regarding light, Michelson invented an instrument with the barbarous name of interferometer. With it he has accomplished some of the most notable triumphs in the whole history of physics and astronomy.

First you must know that light is a wave motion similar to that of water waves. But light is thought to travel in what scientists call the ether of space. This is a wholly imaginary material, or medium. It is entirely beyond the reach of any of our senses. We can not see it, feel it, or weigh it. Still, it seems difficult to believe that light can be a wave movement without something in which to move. And so scientists have supposed an ether to exist.

Away back in 1888 Michelson and an associate, Edward W. Morley, performed a celebrated experiment with the interferometer. It seemed to show that, if this imaginary ether does exist, the earth does not move through it as a ship plows through the ocean. This experiment even made scientists begin to doubt whether there is an ether at all, a doubt that has been growing ever since. In attempting to explain the results of this perplexing discovery, Einstein developed his famous theory of what he calls relativity. To have been the means of giving birth to a new theory of the universe which has stirred the whole world is surely a great distinction for any scientist.

With his interferometer Michelson has been able to measure the diameter of Betelgeuse, as already mentioned, and the diameters of many other stars. Until he showed how, no one would have believed this possible. He has

also shown that the bosom of the solid earth undergoes a very slight tidal movement, due to the attraction of the sun and moon, just as the sea rises and falls with the tide. In fact, this is a tide of the earth's crust.

In many instances, Michelson has proved his ingenuity by inventing the necessary instruments used in his own researches. Medals have been showered upon him by the learned societies of his own and other lands, as well as honorary degrees from leading universities. In honoring him, they honored themselves.

Let me tell you of something which this man of science did, which is almost as much of a triumph as to have determined the velocity of light. He had at one time received an invitation to address a number of scientific societies in South America. Knowing that many of his hearers would not be familiar with English, he determined to master Spanish. At the time he did not know Spanish, although he was acquainted with several other foreign languages. On board the ship which carried him southward, he studied the language in which he wished to speak so well that he was able to make his audiences understand him without difficulty. I am sure you will now agree that Michelson is not only a great physicist but a great scholar as well.

Professor Michelson is still at work in his laboratory, an energetic figure in a field of human activity which never sleeps. It is good to know that there are great souls more interested in advancing knowledge than in amassing wealth.

A Great Chemist

NEARLY twenty years ago it was my privilege to take one course of lectures under Theodore William Richards, long professor of chemistry at Harvard University and probably the most eminent of American chemists. Leading from the laboratory in which I worked was his own private laboratory and office, and he frequently passed by my desk in going to and fro about the building. A thoroughly approachable and lovable man of childlike gentleness and simplicity as well as being a great scientist, all the world mourns his recent and all too early death.

Professor Richards, too, was awarded the Nobel Prize for scientific discoveries. He was probably the most patient and painstaking investigator that we have produced in this country. He was often content to spend a year in preparation for a single experiment and many months in carrying it out. And he not only experimented constantly himself; he directed the work of many others as well. It amazes one to know the amount of such research work that he was able to carry on.

Long before he died, Professor Richards was known as the world's greatest authority on the determination of correct atomic weights. You may think I am crazy to be talking of the weights of such exceedingly minute things as atoms. Utterly beyond the reach of the most powerful microscope, of course no one ever saw an atom, much less weighed one directly. Mind you, I say *directly*. Despite the fact that Professor Richards used balances so sensitive that the slightest breath of air or the heat of the body would disturb them, such balances are a million times too

coarse and clumsy to be able to weigh the heaviest atom. And more, it is wholly impossible to isolate, or separate, a single atom, as we might pick out a particular pea from a bagful.

Nevertheless there are ways of finding with great exactness the weight of an atom of one element in comparison with the weight of an atom of another element, taken as the standard. As any of you who have studied just a little chemistry know, these numbers, which express the relative weights of the atoms, are the atomic weights. I have heard Professor Richards say that they are the most significant set of constants, that is fixed numbers, in the universe. If everything about us and in the depths of space should be resolved into utter chaos, it would still be in accordance with these weights, or proportions, that the atoms of the elements would combine again to build a new universe.

A correct knowledge of these weights makes it possible for chemists to work with greater accuracy. You would not expect an architect to design a building correctly if he were to use a rule which did not give a true measure. In a sense, the atomic weights are the chemist's yardstick. Their determinations must be precisely right, or the chemist will find himself in trouble. Professor Richards determined the atomic weights of nearly a third of the elements, finding in many instances that earlier determinations had been wrong. I recall that one of his assistants, while I was at Cambridge, was working upon the determination of the atomic weight of phosphorus. Before they were satisfied with the result, more than thirty separate determinations were made. This meant a prodi-

gious amount of work of the most careful sort. And the only reward that followed was the knowledge of a truer understanding of Mother Nature and the satisfaction of having performed a real service to other scientists.

Theodore William Richards was a native of Pennsylvania, having been born at Germantown in 1868. His father was a distinguished artist and his mother an author. The whole family was artistic and scholarly, for his brother became a leading botanist and his sister a landscape painter.

At seventeen the future scientist graduated from Haverford College, where he became greatly interested in chemistry and other science subjects. Immediately following he entered Harvard University, to which he was to bring great honor both at home and abroad. Within three years he had won his doctor's degree and had been made an assistant in the chemistry department under Professor Josiah P. Cooke, an eminent American pioneer in this field. In five years he rose to the rank of assistant professor and then went abroad to study at Göttingen, Munich, Leipzig, and Dresden. There, he came to know the leading scientists of Germany. A dozen years later they conferred upon him one of the greatest honors in the gift of their country. They invited him to a professorship in the University of Göttingen with no other work to do than to carry on his own researches and direct those of the most advanced students. However, America could not afford to lose him. Harvard offered him the same privileges and opportunities.

In addition, funds were raised for the building of the Wolcott Gibbs Memorial Laboratory at Harvard, one of

the finest in the world. There, as its director, he spent the last fifteen years of his life, doing the same sort of work as he would have done at Göttingen. And let me say that there is probably no other kind of activity which gives such keen joy as does this work of original discovery. To find some fact which no one else has found before, to unlock some ages-old secret of Nature — that is a joy beyond any power of words to describe. That is the scientist's great reward.

A Master of Research

Not far from the spot where I am writing, close to the shores of Chautauqua Lake, a man who is now one of the world's great masters of research passed his boyhood days. It has always been a matter of personal pride that, although he preceded me by a dozen years, we attended the same high school and that afterward I taught in this school for three years. This man is the distinguished director of the General Electric laboratories at Schenectady, N. Y., Dr. Willis R. Whitney.

I think you might like to hear in Dr. Whitney's own words how he happened to become a youthful chemist. He says, "When I was about fifteen years old a mill owner and one of the leading citizens of my home town, William C. J. Hall, assisted in establishing a Young Men's Christian Association. He had also long been interested in the microscope and was a scientist such as we seldom find among business men today. He formed a free evening class for about half a dozen boys — all that could work together around the rotating table on which he

placed his immense microscope. This was so arranged that specimen, instrument, and illuminating system did not have to be disturbed as they passed from one boy to another for observation. He did not merely show his specimens, of which he had thousands, but he taught us how to prepare them in all the various ways, now more or less common. They were wonderful to me, and are still.

"My mother gave me some money which, combined with that of one of the other boys, purchased a small microtome (an instrument for cutting microscopic specimens), and my father gave me $75 for a microscope. Under Mr. Hall's guidance I bought the instrument, with the understanding that whenever I wanted a better one the old one would be taken back at the original price. I later procured one for $250 which, throughout thirty-five years, I have used almost daily. One of the first experiments I tried with the microscope was to precipitate metallic silver from silver nitrate solution onto a speck of copper filings. Any one who has watched these beautiful crystals grow knows that they are surpassingly wonderful. They constituted my first chemistry. It was those little bottles of salts and bugs in alcohol that led some one to call me a chemist, and it apparently determined my future work."

Not many boys are so fortunate as was young Whitney. Following high school, he attended the famous M. I. T., which some of you know is the Massachusetts Institute of Technology. One day he became so fascinated with an experiment which he was doing in the laboratory that he forgot all about a Harvard-Princeton football game

that he had planned to attend. Upon graduation from "Tech," he became assistant instructor in chemistry. Two years later he went abroad to study, receiving his doctor's degree from Leipzig in 1894. He also studied in Paris and then returned to become instructor in M. I. T. The great interest of his life has been to instruct young men. Once when a flattering commercial position was offered him, he said, "I would rather teach than be President." Teaching and the solving of the problems of science and industry give him his great delights.

And yet I should not forget to tell you that Dr. Whitney has a number of hobbies. At one time he was immensely interested in raising turtles on his farm. At another he became an expert on Indian arrowheads. He has studied prehistoric men and heredity. On his farm he has experimented with agricultural problems.

In 1900 Dr. Whitney was called upon to establish at the General Electric Company the first great industrial research laboratory in this country. For a considerable time he traveled to and fro between Boston and Schenectady, dividing his time between M. I. T. and the new laboratory. Gradually the work of the laboratory took more and more of his time, until at length he had to abandon Tech. But he did not feel that he was giving up teaching, for under his direction he had a small army of young men. Their work was what we call research. It is of two kinds. One has to do with the solution of problems connected with the big industry of which the laboratory is a part. The other is to make discoveries in what we call pure science. That is, these discoveries may seem only to add to our knowledge of Nature's forces.

In making them the scientist does not ask whether they will ever have any practical value or not, anything which can be converted into dollars and cents on the balance sheet.

It is in this second kind of research that Dr. Whitney has, if anything, been most interested. Let me illustrate with an example. Incidentally, I shall tell you of one of his most brilliant research men and one who formerly was president of the American Chemical Society.

Twenty years ago this summer (1929), Dr. Irving Langmuir went from his post as instructor in chemistry at Stevens Institute up to the laboratories of the General Electric Company to spend his summer vacation. Dr. Whitney told him that he might browse about for several days until he found some problem that interested him. Just at that time the whole laboratory force was experimenting with tungsten wire, now used as the filament in our electric lamp bulbs, and also in our radio bulbs. Out of a large number, three samples had been found which worked as well on alternating current as on direct, but no one knew why. They were trying to discover the reason. That is research of the first kind. These men were trying to solve a definite problem.

It seemed to Langmuir that the impurities in the wire in the form of gases might have something to do with this curious circumstance. And so he began to study the gases given off by a hot filament in a lamp bulb. The weeks of the summer passed quickly by. The work was fascinating, and Langmuir dreaded to go back to the task of teaching. Whitney told him that he might stay on. He was given first one assistant and then three. Much

of the apparatus that he needed in his experiments he devised himself. Langmuir was a natural research worker.

Up to that time everybody had supposed that the way to get a better electric lamp was to make a better vacuum in the bulb. That is, to pump out more and more of the gases. Whitney believed this too. But Langmuir began to ask questions. He deliberately put various gases into the bulb and thus spoiled the vacuum. He wanted to see what would happen. Some might have thought him only playing. For a long while he did not seem to be getting anywhere. He did not seem to be doing anything that was at all practical. Time and again, he went to Whitney and told him this. But Whitney replied that it did not matter, so long as this work of Langmuir's added to their knowledge of the electric lamp. And so he worked on. Yes, for three years, and then he gave to the world the gas-filled bulb. This is the now familiar bulb containing either the rare gas argon or nitrogen. As you know, it gives a light of wonderful brilliancy. What you probably do not know, however, is the fact that these gas-filled bulbs subtract a million dollars a night from the electric light bill of the American people, as compared with what the cost would be with the lamp it displaced. Here is an example of pure research. As so often happens, it turned out to be of the most practical sort.

Langmuir, too, has done much else. Recently, he produced a new type of flame. It is used in welding metals and gives the highest temperature of any flame known to science. He calls these flames, "flames of atomic hydrogen," for it is really atomic hydrogen that he burns. Much

of the improvement in your radio bulbs is due to his work. But you do not think of this when you tune in for distant stations. You little realize the patient experimenting which makes possible the marvelous advances in the radio art.

This is the kind of discovery which is being made under Whitney's direction. Do you wonder that I call him a "master of research"?

Probably most of you have read something about the wonderful new cathode ray tube invented by Dr. W. D. Coolidge in those same laboratories. In its latest form it uses nearly a million volts and produces effects equal to those of more than a ton of radium. This tube shoots electrons into the air at speeds almost equal to that of light. Its rays kill germs and spores, and they produce brilliant lighting effects and many chemical changes. Just what its practical applications will be, no one entirely knows yet. But before this book gets into print, the story may be old.

Whitney is a "human dynamo." He is here, there, and everywhere about the laboratories, and he inspires his men with his own enthusiasm. He has hosts of friends. Probably no other man of science is better loved by his associates and those who know him. Although past sixty, he has the energy of a man twenty years his junior. Under such leadership as his it is not surprising that marvelous things come to pass.

Honors, degrees, and medals have come to this leader of research. But long after these are forgotten, he will be remembered for his enduring achievements and his kindly, generous interest in his fellowmen.

America has produced many other scientists in the last half century. Their work has had much to do with the building of our great industries. Through their discoveries and the applications made of them, men have come to know that all progress rests upon increased knowledge. To know the truth and then to follow it is the great lesson of science. I hope these brief sketches will make you want to learn about others of these explorers of Nature.

CHAPTER VIII

PATHFINDERS

I WANT to tell you now something of another kind of scientists. I shall call them pathfinders. They were more than scientists. They were pioneers as well — almost adventurers. They saw visions and dreamed dreams — these men did. What is more, they made their dreams come true. And because they did, this world is a more enjoyable place in which to live. Without knowing it, we benefit, all of us, in countless ways from their excursions into new fields.

A Lonely Pilgrim

Scores of men now living can remember when the wheat crop of the Great West was often a failure. That is, it was a failure in many places. There was no certainty about it. Drought, rust, or the cold of winter ruined vast acreages and brought hardship to hundreds of homes.

Then, there came a man, a prophet of a new day, who dreamed of changing all this. He believed that somewhere in the world grew a kind of wheat so hardy that it would be able to resist the severest weather and every natural pest. Gradually this idea took possession of his soul. It crowded every other thought from his mind.

Awake or asleep, he dreamed of it. Somewhere this kind of wheat was growing. It could and must be found. And so Mark Alfred Carleton became a lonely pilgrim in what often seemed an unfriendly world, searching always for a wheat which would transform agriculture in the great grain belt of his native land and make this region the granary of mankind.

How Carleton brought the Kubanka durum wheat from its ancient home on the steppes of western Asia and watched it spread to more than four million acres of our Northwest is a fascinating story. And he also brought from the cold, bleak, wind-swept areas of northern Russia the Khardkov wheat now grown on twenty million acres of western lands.

Carleton was born in Ohio in 1866, but when he was ten years old his parents moved to Kansas. There he saw the ruin to the wheat fields which followed the coming of the black rust. He never forgot the clouds of spores that filled the air and irritated the nostrils of animals and men. Then and in the years of his young manhood he saw the hot dry months of summer parch the fields of grain; he saw the autumn winds from the mountains blow the wheat out of the ground; he saw the icy cold of winter kill the wheat which was to yield a crop in the spring; more than all this he saw the suffering and the want visited upon hard-working men and women and innocent children from this pitiless and losing battle with Mother Nature. From it all came the resolution in Carleton's mind to " find the wheat that will stand the worst."

When he was twenty-one Carleton graduated from the Kansas Agricultural College. He was now a botanist.

With all his energy he gave himself to the study of wheat and the baffling rust which threatened its life. In his evenings he studied Latin and Greek that he might become familiar with the scientific names of the weeds, grasses, wheats, and parasites which he saw on every hand. For a time he taught natural history in Wichita University. Then he obtained a position with the State Experiment Station at Manhattan, Kansas. To know wheat and to improve it became his very life.

When he had been six years out of college, Carleton made an important discovery. Before that time everyone believed that rust on one kind of grain could pass directly to another. Carleton doubted this. There was only one way to know. He must experiment. So he set some young oat plants covered with the black stem rust in the midst of a piece of wheat. The wheat remained free from rust. Then he set wheat plants sick with the particular kind of black rust which kills wheat in the midst of a thriving piece of oats. The oats stayed healthy, free from rust. These and other experiments proved to this practical-minded man that a rust parasite can not jump from one kind of grain to another. This was a first step in his battle for the wheat farmers of the West.

News of this discovery spread abroad. It was carried to Washington. Carleton found himself to some extent famous. The Government placed him in charge of all the work on wheat. His salary was not large, but that did not matter. He was not working for money. If he could save the wheat industry of the plains and prairies which he loved, that would be sufficient reward.

He sprayed wheat for the sowing with chemicals, but

they did not prevent the rust. Surely, there must be a kind of wheat somewhere in the world able to resist the billions of spores that cause disease. He must find it; there was no other way. His first step was to gather from every quarter of the earth samples of wheat. In due time little packages containing these samples began to pour in — more than a thousand of them. They came from Japan, Siberia, Russia, Australia, Germany, Turkey, Italy, and from many other places.

He sowed these wheats in little experimental plots in Maryland. But the deadly rust which afflicts the wheat of the West did not appear. The climate in Maryland was different. Gradually the idea grew in his mind that the place where he should be making his tests was back in Kansas. That was the country he loved too. After a year in Washington he went back, carrying with him his precious samples of wheat. There, he made tests, but most of his varieties did not survive the severe winter that followed.

Now another idea began to possess the mind of this man who had gone "batty" on wheat. In his wanderings through the wheat belt, Carleton had discovered that certain Russian immigrants were raising a wheat, brought from the fatherland, much hardier than American varieties. Out there in Russia, there must be wheat that would beat off the summer drought, the winter cold, and the black stem rust. He must go and find it.

Carleton pestered his superiors in Washington until they granted him permission to go on this quest. On July 4, 1898, he left for Russia.

For months he stalked amidst the wheat fields of a

strange land. Before setting forth, he had mastered the rudiments of the Russian language. By gestures, broken Russian and some English he made himself understood. Everywhere he asked about the kinds of wheat that best stood the bitter cold and the winters in which there was little snow. For snow, as you know, acts as a warm coverlet to protect the roots of plants and trees.

At length, on the Turghai steppe of western Asia, he found a hard durum wheat called the Kubanka. It had been growing there for centuries, and it seemed to possess all the qualities that Carleton sought. He had accomplished that for which he had crossed the ocean and half a continent.

Back with this new wheat he went to his own country. Then began the struggle to get farmers to grow it and millers to grind it. He sent samples of it everywhere in the wheat belt. Soon it began appearing at the mills, but the millers raised a cry against the newcomer. They complained that their machinery would not grind the hard glassy kernels. But Carleton continued his fight. To show the superior qualities of his new wheat, he had sample loaves baked from it and sent them, together with loaves baked with flour from other wheat, throughout the land.

Months and even years passed, but Carleton never ceased in his campaign. Gradually it began to tell. The news spread. Farmers began to tell of the large yields and the hardy nature of the new wheat. Millers discovered that they could grind it after all their fuss. Then came the big triumph of 1904. In that year the black stem rust blasted large areas of the ordinary wheat. Much of it was not

worth cutting. But the rust scarcely touched the Kubanka durum. Wheat-growers, millers and even Carleton himself were astounded. Kubanka had won, and it was a great victory. In five years this new wheat had reached a production of twenty million bushels.

In the meantime this prophet of a new era in the development of an agricultural empire had returned to Russia. He wanted a new winter wheat as hardy as the Kubanka. Somewhere in Russia he believed he would find it. And he did. At Starobelsk, where the summers are hotter and drier and the winters colder and more severe than they are anywhere in the wheat fields of the West, he discovered Khardkov, which scored as great a success as Kubanka had done. And it won without a fight. Wheat growers had come to know that Carleton was a pathfinder whom it was wise to follow.

I wish I could tell you that Carleton received the reward that was his due. Sickness came into his family. His salary was never large. Debts accumulated. Business ventures in which he had hoped to retrieve his fortunes were failures. At length, they cost him his job with the government service. He drifted to South America, sending back money from time to time with which to pay his creditors, and dying in Peru in 1925, a lonely pilgrim in a foreign land.

A Blazer of New Trails

One day in the summer of 1914, just before the outbreak of the World War, I wandered into the chemistry building of the agricultural college of the University of Wisconsin.

Presently, a kindly old gentleman, with white beard and pleasant smile, greeted me and asked if I were a visitor and would like to be shown about. After a delightful hour, I discovered that my host had been no other than Professor Stephen M. Babcock, a man who has blazed new trails and pointed the way to important advances in the conquest of hunger, both among beasts and men.

When I say that Professor Babcock invented the famous Babcock milk test for finding the percentage of butter fat in milk, many of you will know by name at least this pioneer in a new field of chemical investigation.

In 1888, when Professor Babcock was forty-four, he became a member of the chemistry department of the University of Wisconsin at Madison. Babcock, a boy from Oneida County, New York, had been a student at Tufts College and Cornell University. He had also been abroad and held a doctor's degree from a German University. For a number of years he had been a chemist at the Agricultural Experiment Station at Geneva, New York.

When he arrived in Madison, Dean Henry of the department told Babcock that the state was in great need of a simple test for the amount of butter fat in milk. Milk was sold in those days by the pound. Creameries and cheese factories made no difference in price between good milk and poor milk. Indeed, they had no way of knowing which milk was good and which poor. Skim milk or watered milk, if undetected, brought the same return per pound. Science had not then entered the milk business.

Babcock went to work. Before long he had several fairly good tests, but not good enough. None satisfied

him. They could not be depended upon in every instance to separate all the fat. He persisted until he had a test which seemed to be perfect, and it has been regarded so ever since.

I presume many of you have seen this test carried out. Many farmers use it daily. In this way they can tell just which cows in a herd are profitable and which are not. I used to carry out the test in my chemistry classes every year. I sometimes do yet. There is something fascinating to me in the separation of the fat and its accumulation, golden yellow, in the neck of the bottle.

This invention made Babcock famous. It was soon in use, not only in this country, but in Europe and throughout the world. He did not patent the method, as he might, and has derived no financial benefit from it. The State of Wisconsin awarded him a medal, and he received grand prizes at both the Paris and St. Louis Expositions. Ex-Governor Hoard of Babcock's adopted state said, " The Babcock test has made more dairymen honest than the Bible has ever made." No longer was it safe to skim the cream from milk or to water it, if that milk was to be offered for sale.

Every state or city now prescribes a certain minimum percentage of butter fat which milk must contain. It is the practice of a large milk distributor to mix the milk from various herds so as just to meet this requirement. Without the Babcock milk test this process of mixing would be largely guesswork.

Had Professor Babcock done nothing else during his busy life of more than four-score years, he would be sure of a place among the pathfinders of his country. But this

discovery was only an incident. His great work lay in another field.

When Professor Babcock was in Germany, he found the chemists of that center of science and learning firm in the belief that chemical analysis would tell all the qualities of a cattle feed. It seemed as simple as ABC. If one knew the ingredients, or different chemical compounds, in the rations for a cow, for instance, he could prepare an artificial food that would do just as well. We sometimes hear it said now that the time may come when three portions of laboratory-prepared pills a day will take the place of three square meals. Mother Nature has always produced our food in her own marvelous laboratories in the living cells of plants and animals. But here were chemists in Germany and other countries confident that they might equal or even improve upon her methods. For a time Professor Babcock came to believe this too.

But a series of experiments at the Geneva Station soon shattered this fond dream. Hidden in foods was something absolutely essential to health and growth. Chemical analysis could not reveal it. It was a baffling problem. Gradually scientists began to know that there was one, probably several, mysterious but vital substances present in natural foods. Without them disease and often death followed. However, it was years before the truth was uncovered. In the pathfinding work of doing so, Professor Babcock led the way. He was the torchbearer.

It became perfectly clear to this new prophet that the only way to find the truth about the necessary ingredients in the rations of animals was to experiment with animals

themselves. But for years he could not get the animals with which to experiment.

At length his opportunity came. He obtained sixteen perfect heifer calves for his tests. Two assistants, Hart and Humphrey, young men who have also become renowned, carried out the tests. The calves were divided into four groups, and to each group was fed a different ration. The weeks and months passed and the months grew into years, but the experiments were continued. Strange things began to be apparent. Important discoveries were being made.

According to the earlier ideas regarding the chemical ingredients of foods, each group of calves was getting what is called a balanced ration. Each ration contained the proper quantities and proportions of fats, carbohydrates, proteids, and mineral salts. Still, one group of animals, that fed on corn products, thrived famously. The others did not. Surely, the corn must contain some vital principle which the other rations lacked. There could no longer be any question of this. It was a fundamental discovery — this. But chemical analysis was unavailing. It could not reveal what this mysterious something might be. In due time the truth appeared.

Babcock had blazed the way — a way which led to the discovery of the vitamins. About these, I have told you in another place.

It is good to know that this explorer along a pathway the end of which has not yet been reached is still at work in his laboratory, with abundant evidence of his achievements on every hand.

A Corn Doctor

If you think I am about to tell you of the only sort of corn doctor you have ever heard, you will be disappointed. The corn doctor I have in mind just now is a man who has shown how to cure some of the diseases that afflict maize, or Indian corn, the grain which the white men found growing in America when they first came to these shores. He is a pathfinder to larger crops and better quality of grain. He has shown how to make old worn-out soil yield like new. His name is George Hoffer, a botanist at Purdue University in Indiana, right in the heart of the corn belt of the great Middle West.

He was born on a farm in Lebanon County, Pennsylvania, of Dutch parents. After graduating from Lebanon Valley College in his native county, he attended Columbia University. His vacations were often spent in taking trips of scientific interest. One summer he went to Bermuda and another was passed along the shores of Chesapeake Bay. On both he gathered strange forms of life. Some of them we call fossils. These are the forms of ancient life which ages ago left their impress in soft muds, now hardened into rocks.

In those student days Hoffer little dreamed that he was to become a well-known expert on corn and the troubles which interfere with its healthy growth. When he came to teach in this mid-western university, he knew little about corn. He did not know that corn had any troubles or that anything could be done about them if it did. It was a student in his classes who brought a whole brood of corn troubles to Hoffer's door and left them there.

As you know from your study of American history, corn was one of the first crops grown in this country. You probably know, too, how the Indians taught the white settlers to plant a fish in each hill of corn. This produced better crops, and often made old land for a time yield like new. Of course, neither the Indians nor the white men knew why. That is what we call "rule-of-thumb" science. It worked, and that was all that was asked.

You remember, too, how Daniel Boone and his followers grew great crops of corn and tobacco in the "Dark and Bloody Ground." That was new soil. It had all the elements necessary to make plants grow, and in particular to make corn grow.

Another thing the settlers had discovered. Sometimes they returned to abandoned land — land that had become so poor that it would not grow anything. In this period of abandonment, a dense growth of small trees and underbrush had sprung up. Someone would burn this over, grub out the roots and plant the ground with seed. Once more the land seemed to have gotten a new lease on life. Again no one knew why. Of course, they learned by this, however, that wood ashes contain something that plants need. The ashes left from burning the land over renewed its fertility.

Then, too, still another factor had been discovered about the cultivation of corn. Men found that a certain kind of corn, grown year after year, would "run out." The large crops and good, full kernels would disappear. Here and there, some farmer would begin to select the largest and plumpest ears for next year's seed. He did this

year after year, and often his corn for a time became famous. At length came men who learned how to breed different varieties of corn, just as stockmen breed horses and cattle. This gave better seed corn.

Still, neither corn nor any other crop can grow well in poor soil. When Hoffer came to teach botany at Purdue, the land in many parts of the country east of the Mississippi was growing old. It no longer produced such lusty crops as had gladdened the hearts of the early settlers. Then, too, plants, and corn in particular, often got sick. Without any knowledge of corn and its ills, Hoffer was called upon to remedy the situation.

Hoffer's student, James Holbert, brought to him corn stalks which had broken down at the joints and whose tangled mass of roots was covered with molds. The kernels, too, were moldy. What was the trouble? Why should this be so? Hoffer did not know, but he made up his mind to find out. Thus began a search which lasted for years, and which has only recently come to success.

The first discovery of Hoffer and his student was to show that diseased corn should not be planted as seed the next year. But this did not stop the stalks from breaking down or the molds from coming.

Hoffer had noticed that the joints of stalks which broke down were brown in color. He believed that in these brown joints must be the molds that caused the trouble. He set students to work to find them. But no molds were there. Even the microscope would not reveal them.

Then came a happy accident. A canner of sweet corn complained to Hoffer that his canned goods were being returned, full of black specks. Chemists reported that

these specks were iron and probably due to flaws in the cans. But the cans seemed perfect. This gave Hoffer, who had now turned corn doctor, a new trail to follow. Could it be possible that this iron came from the corn itself?

There was only one way to tell. Hoffer must make tests. He did so immediately, and both the corn and the stalks at the joints, where the brown color appeared, showed strong tests for iron. It now seemed probable that this abundance of iron might clog the sap tubes and prevent the circulation of sap necessary to the healthy growth of stalk, leaf and ear.

More experiments were necessary. Hoffer knew that the dye known as methylene blue would penetrate quickly to every part of a living tissue. It had been the staining power of methylene blue that started Paul Erlich on his great quest for a cure for sleeping sickness and led him to one of the greatest medical triumphs in half a century. Hoffer cut off corn stalks and dipped the cut ends in water containing this dye. His idea was correct. The dye was stopped at the brown joints where the iron had accumulated. It seemed, too, that the iron must have something to do with starting the molds.

But why did these iron attacks come in some fields and not in others? That, Hoffer must discover.

By chance he learned that aluminum, another element always present in clay soils, is bad for corn, and by experiment he proved it. He also learned that lime and phosphates in the soil would remedy the trouble. His experiments seemed to show that this was true too. Then he staged a big experiment on a nearby farm having very

poor soil. But the trouble was still there. The broken brown joints and the molds were as thick as ever. The secret had not been discovered.

Next a man named Howell down in North Carolina got into communication with Hoffer about his corn troubles. Newly cleared soil, which had at first yielded large crops of corn, quickly wore out. Something must be done. Hoffer advised the use of lime and phosphates.

Howell did as he was told, but he did more. He had read that potash is a necessary plant food, which of course was nothing new. This had been known ever since Baron von Liebig had made the discovery nearly a century before. Hoffer of course knew it too. But into some of his experimental plots Howell put potash as well as lime and phosphates. Then he waited for results.

In due time they came. Mother Nature performed just as she would have done all along, had anyone known how to treat her. The plots planted with lime and phosphate told the same old story. There were the molds and broken brown joints. But, lo, where potash had been used everything was as it should be. The stalks were straight and strong; the leaves were vigorous; and roots and ears were free from molds.

Here was a great discovery. Hoffer repeated the experiments with similar results. At last the pathfinders were on the home stretch.

Still, much remained to be done. How were farmers to know just what fertilizers to use on their sick soils. Not all would need the same treatment. Hoffer must develop simple tests to tell the story. And he did. He

showed farmers how to test their soil and to know what kind of fertilizers to use. On much of the soil east of the Mississippi potash is needed. This prevents iron and molds and increases the yields. Old acid soils need lime, and some soils need phosphate. So also do most aging soils need nitrates.

It was a long hard trail that this pathfinder followed, but he found the " pot of gold " at the end of his rainbow of hope. Another corner had been turned on the highway to successful agriculture.

Now we know why the fish which the Indians told the white men to plant with their corn made it grow. The bones of the fish supplied limestone and phosphates, and the fleshy parts some nitrogen, all essential to plant growth. And the ashes left on the burnt-over land provided potash. Indeed, wood ashes was one of the original sources of potash, and the name came from burning wood in pots to get ashes.

Although a real victory has been won, we must not think that all the problems about the growing of corn have been solved. Probably they never will be. Undoubtedly, the corn doctor will always have plenty to do.

A Conqueror of Disease

I CAN not close this chapter without telling you just a word about a conqueror of disease. Only this battler with the baffling myriads of microbes did not make war on human disease. Instead, he fought to a standstill the treacherous hog cholera which not so many years ago swept over the Middle West at frequent intervals, taking toll of thou-

sands of these domestic beasts and bringing scores of farmers to the verge of ruin.

This foe of disease is Marion Dorset, still carrying on warfare against other microbes in his laboratory in Washington and born in Tennessee back in 1872. He studied medicine, receiving the degree of M.D. from George Washington University. He has taught subjects having to do with bacteria, small living organisms which often produce disease, and also what is called pathology, or the science of disease. But most important of all that he has done is his conquest of hog cholera as a chemist in the service of the Department of Agriculture. The battle lasted for ten years or more and at times seemed almost hopeless.

As we have just seen, corn is one of the great crops of the West. And one of the chief uses of corn is to feed pigs to convert them into pork for eastern markets. But if the hog cholera comes along and kills these pigs, both the corn and the animals are lost. Furthermore, great hardship is brought into hundreds of homes which depend for their living and prosperity upon this combination of agriculture and pig raising.

Before Dorset was sent out to Iowa in the 'nineties of the last century to fight this malady, Dr. Salmon and Dr. Theobald Smith of the United States Department of Agriculture believed that they had discovered the particular microbe responsible for it. They had also prepared a serum which they were sure would keep well pigs from coming down with the disease. Most of you know what a serum is. Many of you have been inoculated, as we call it when the doctor injects a serum into your veins, against

Courtesy of the Canadian National Railways

A glimpse of the agricultural empire that Carleton did much to make possible

The Pacific Terminal of the Panama Canal

such diseases as diphtheria, scarlet fever, typhoid fever, or pneumonia. The serum puts into the blood an army of friendly microbes which fight the disease-producing microbes and often defeat them.

Armed with this serum, Dorset went to Iowa during one of these epidemics when hog cholera was doing its worst. But the serum did no good. The animals into whose veins it had been injected took the cholera and died with it just the same. Before the irresistible march of the insidious disease, Dorset stood powerless. But he did not surrender. He determined to fight. And thus the warfare began.

The clue to the final victory came with the discovery that certain of these beasts which came down with the fatal malady did not die but in time got well. Then they became, as we say, immune. That is, they would not again take the disease. Into the veins of one such recovered pig, Dorset shot a whole pint of blood reeking with cholera microbes from an animal which had just died. He considered this enough, if it had been properly divided up, to kill a hundred and twenty million ordinary pigs. But this pig seemed to thrive on it. It remained well and healthy. Surely, something must have happened in its blood to enable it to fight off the invading army of hostile microbes. If Dorset could just succeed in giving all well pigs such wonderful immunity, the battle would be won.

Success did not come just then, not until years after when another attack of the cholera arrived. Then Dorset returned to the battlefield. Into the veins of a healthy pig he injected a mixture obtained by mixing blood from a pig dying of cholera with blood from one which had

been near death and had got well. To his great satisfaction, this experimental pig remained well. Even when put into a pen full of sick pigs, he did not take the disease. At last Dorset seemed to have discovered a way of keeping healthy pigs well.

But he wanted to be sure. So into each of four pigs to which he had given his treatment, he injected enormous quantities of blood from sick pigs, dying with the disease. Still, not a one of these four animals got the cholera. They were thoroughly immune.

Then Dorset tried another experiment. Into perfectly healthy pigs, he injected serum from the blood of one of these redeemed pigs. But he did not mix with it blood from a sick pig, containing the microbes of the disease he was fighting. He turned these animals loose among pigs sick unto death with cholera. One might have supposed that these test pigs would remain well. But they did not. They kept well a little longer than untreated pigs. That was all. In the end they died.

Once more Dorset returned to his experiments. Into the hind leg of a healthy animal, he injected blood from a sick pig. Into the other hind leg, he injected his protective serum. He repeated this with five others. Then he waited. Nothing happened. But the test was not complete. He let these pigs, together with six untreated ones, loose among a lot of cholera-stricken beasts. Again he waited. One by one the untreated pigs sickened and died, but the treated pigs remained as well as ever.

Victory had come. Dorset had discovered how to banish hog cholera from our western farms. It was a great triumph and one which has meant millions of

dollars to the agricultural wealth of the nation. But, as you can see, it did not come by magic. Such victories never do. The man of science must experiment with infinite patience through months and even years of anxious waiting.

The serum for the prevention of hog cholera is obtained, as we have seen, from animals which take the disease but recover. The blood of these immune pigs is drawn and allowed to clot. The clear liquid which separates from the clotted blood is the serum. This carries the natural enemies of the deadly microbes. These enemies give the animal the advantage in the fight for life. In fact, an animal protected in advance with this serum does not take the disease at all. He is like a garrison inside a fort too strong for capture.

Quantities of this serum are always kept on hand by the proper authorities. More can be prepared whenever the epidemic returns by making use of the particular animals which seem to build up resistance to the disease and in that way acquire natural immunity.

CHAPTER IX

THE BATTLE WITH DISEASE

YOU YOUNG readers of today, and many of us older ones as well, simply can not understand how appallingly ignorant the world was about the cause and treatment of disease even so recently as a half century ago. Most of the great discoveries in medicine have come since the Civil War. Although ether and chloroform were in use at that time, the real knowledge of disease had not emerged from the Dark Ages into the bright sunlight of modern triumphs. People talked gravely of mysterious "miasmas," "bad airs," and the Will of God. The existence of air-borne microbes was not even suspected. And then the picture changed.

Sometimes I am carried in imagination to a little room in a Paris hospital. It is the year 1885. Before me I see an old man, old before his time in the service of his country and in the battle for suffering mortals. He is keeping anxious watch over the still form of a peasant lad. Eagerly, he scans every symptom. For two weeks, he has scarcely eaten or slept. Life is precious to him, and this is to be his crowning achievement in snatching men from death. Will the lad die, or will the new-found vaccine with which he has inoculated his veins bring the dread malady of rabies under the control of preventive medicine,

even as anthrax and other contagious diseases have been? The answer is written large in letters of living light, for the lad lives, and all the world has learned to bless the name of Louis Pasteur, father of the germ theory of disease and with his comrade Lord Lister across the Channel one of the first great apostles of antiseptic surgery.

This great Frenchman had caught the vision of a new day in medicine. He said, "Perhaps, I can save more lives than were lost in the Franco-Prussian War." And he did, many times more. But it was in the chemical laboratory, working largely with the microscope, that Pasteur made his great discoveries. We of today no less than yesterday need his message, when he said, "Take interest, I implore you, in those sacred dwellings which one designates by the expressive term laboratories. Demand that they be multiplied, that they be adorned. These are the temples of the future — temples of well-being and of happiness. There it is that humanity grows greater, stronger, better."

And I would not have you think that the battle with disease has been won. Far from it. We have taken great strides in the conquest of the infectious diseases, such as typhoid, diphtheria, scarlet fever, cholera, lock-jaw, smallpox, and many more. But the deep-seated organic troubles are more threatening than ever. Diseases of the kidneys, hardening of the arteries, heart disease, pneumonia, the retreating foe of tuberculosis, influenza, the common cold, and insanity are still vigorous enemies of mankind. In a way, this ages-old fight has only begun.

Now, I wish to tell you of some of the men in our own country who have been leaders in this greatest battle of

modern times. Emerson once said, "When Nature has work to be done, she creates a genius to do it." Certain it is that in Major Walter Reed, a surgeon and doctor of the United States Army, the world found the genius who was able to win the first decisive battle in the conquest of yellow fever.

As a boy, Reed lived in the South, having been born in Virginia in 1851. At once you can see that this made him a lad of fourteen years when the Civil War closed. Of that war he had many vivid recollections. In 1865, when Phil Sheridan and his raiders invaded the country near young Reed's home, Walter and an older brother were sent by their parents to hide some horses. Having tethered them completely out of sight, behind some trees at a bend in the river far from any dwellings, the boys went for a swim in a nearby pool. Soon, however, guided to the spot by a faithless servant, the soldiers appeared, seized the horses and took the boys into custody. When the soldiers discovered how young their prisoners were, they let them go, but they drove off the horses, much to the dismay of their youthful guardians.

This lad whose discoveries in later life were to free a great island of the Western Hemisphere from a frightful malady and make possible the digging of the Panama Canal, received his early training in a private school of his native state. When sixteen, although under age, he was allowed to enter the University of Virginia. He wished to become a doctor, but the faculty discouraged him, believing him too young to take the course. Finally, it was agreed that he should be permitted to try. If he did the required work and successfully passed the exami-

nations, he should have his degree of M.D. However, no one believed it possible for him to do this. I do not need to tell you that he succeeded brilliantly, graduating third in his class.

A course in medicine in those days was much shorter and less exacting than it is now. But the winning of his degree meant for young Reed that he had only begun his training. Soon, he went to New York, where he became a student in the Bellevue Hospital Medical College, a year later earning another degree of M.D. He now became an interne, or assistant, at the King's County Hospital in Brooklyn. Here and in other hospitals in New York he received excellent preparation.

Still, the general practice of medicine did not seem inviting. At length, he decided to become an army surgeon. Of course, he knew that this would mean many years of rough life in army outposts in the Far West. And those were times when the Indians were still on the war-path. Possibly, this very fact appealed to his young and adventurous spirit. I am sure it would to many of you.

And so this youthful doctor in a short time found himself preparing for the very severe examinations for a medical post in Uncle Sam's army. This was probably the most trying ordeal of his young life. The examination was to last five hours each day for six days. To his dismay, he learned that there were more than 500 applicants for less than 30 vacancies. Time and again he despaired of success, but he would not turn back. At length, the much dreaded examination week arrived and passed. Soon the would-be army surgeon learned that he had succeeded as brilliantly as he had done in his medical

course. In June, 1875, when only twenty-four, he received his commission as Assistant Surgeon, with the rank of First Lieutenant.

His first post was in Arizona. For sixteen years, he was to continue the garrison life there begun. It would take many pages to tell of his experiences. Danger and hardship were frequently the order of the day. Reed counted it his duty to care for the sick and suffering among soldiers, settlers and Indians alike. He never failed to heed a call for help. Then, one glad day in 1891, he received an order to return East. He had long wished to take up once more his scientific studies. Now, this wish was to be granted.

Stationed at Baltimore, he began professional work in the Johns Hopkins Hospital. Later, he became a professor in the United States Army Medical School in Washington. Although eager, when the Spanish-American War broke out, to go to the front, where he might use his knowledge and experience in caring for the hundreds of sick soldiers, this was not permitted. Poorly prepared, political favorites were often chosen instead.

Still, Reed's golden opportunity was coming. Of that opportunity and what it has meant to the world, I want to tell you now.

In the two years following the American occupation of Cuba, more soldiers had died from yellow fever than were killed during the war by Spanish bullets. Soldiers and natives alike fell victims to this tropic foe of human beings. Still, no one knew why. General Wood, the American commander in Cuba, cleaned the city of Havana, the disease center of the island. He made the unwilling Cubans scrub themselves and remove filth.

Still, the ruthless march of the "yellow jack" was not stopped. It was not even slowed up. Conditions were becoming desperate. General Wood cabled to Washington. In June of this year 1900, Major Walter Reed arrived in Havana with orders to "give special attention to questions relating to the cause and prevention of yellow fever." Reed had long dreamed of some day winning a great victory in the conquest of disease. No greater opportunity could have been asked.

On June 25th, he unpacked his grip at Quemados and in grim earnest began his search. He lost no time in examining the blood of patients dying with yellow fever. Still, not a microbe could be found. Soon, however, he came upon two clues. He noticed that the nurses who cared for yellow fever patients did not take the disease. And he made the acquaintance of a "crazy" old native, Dr. Carlos Finlay, who had the queer notion that a certain mosquito spread the malady from victim to victim.

How could he test this idea? There was only one way. He must try experiments. But a big question mark immediately cast its shadow across this method. No animal had ever been known to have yellow fever. Furthermore, animals could not be made to take it. To experiment with rabbits and guinea pigs was out of the question. What did this mean? Why, that human beings would have to supply the living laboratories for making the tests.

Major Reed called upon his staff for volunteers. To their everlasting credit, Jesse Lazear and James Carroll, knowing that it might mean a horrible death, immediately offered themselves.

How were the tests carried out? Many of you know

that these men allowed themselves to be bitten by mosquitos of the particular kind thought to be the carriers of yellow fever. Furthermore, the mosquitos chosen to play this part in the tragic drama to be enacted were known but a few days before to have sucked the blood of patients in the last stages of the disease. As had been hoped, both men came down with the horrible malady. For many days, both wavered between life and death. Then Carroll recovered, but the brave Lazear did not. Within two weeks from the time of the experimental bite, his heart ceased to beat, and he forever wrote his name high among the immortals.

It now seemed fairly certain that yellow fever is transmitted by a mosquito. But the experimenting had only begun. Through the co-operation of General Wood, Major Reed was able to offer two hundred dollars apiece for native volunteers. Five presented themselves, and in addition Private Kissenger and John J. Moran, a clerk in the office of General Fitzhugh Lee. Soon Kissenger and four of the natives were sick unto death. An unknown something was coursing through their veins, giving them severe aches and pains and turning their skins yellow. Fortunately, all recovered. The certainty that he was on the right trail grew in Major Reed's mind.

One doubt, however, must be removed. As long as could be remembered, everyone, physicians and people alike, had believed that the bedding and clothing of yellow fever patients were poisonous. Again, there was no way of telling except by experiment. The fact that nurses did not take the disease had led Major Reed to suspect the truth of this belief.

He established an experimental camp, named Camp Lazear in honor of the first hero of the cause. There he built a small house. Soon one might have seen men enter the building carrying boxes from the death wards of the yellow fever hospital. Out of these boxes, they removed bedding and clothing, soiled with the black vomit and discharges of men who had died from yellow fever. Then, three volunteers, an American doctor named Cooke and two soldiers, Folk and Jernegan, entered the small house. With those foul sheets, blankets and pillow cases, they made their beds. Then, clad in the pajamas of men who had but just fallen victims to the frightful malady, they lay down to sleep. Night after night, these brave men slept in those loathsome surroundings. But not a one of them became sick. This ancient belief had been proved a myth. Yellow fever could not be transmitted through the clothing of its victims.

Anyone but a thorough going scientist would have been convinced. But Major Reed was not satisfied. There still lurked the suspicion that something in the air might carry this disease. Accordingly, he built another house. With a fine-meshed screen, he divided it from top to bottom into two compartments. Each compartment was provided with plenty of light and air. In one, he placed a volunteer soldier and let loose upon him fifteen mosquitos which had but recently fed upon yellow fever patients. For two days in succession, these mosquitos were allowed to bite this soldier. In the other compartment, the Major placed two soldiers, but he guarded them with the utmost care from mosquitos. For days and weeks, these three soldiers lived there, all breathing the

same air, getting the same degree of sunshine and surrounded in every way with the same conditions. Only the soldier bitten with mosquitos fell a victim to yellow fever.

No longer could there be any doubt. The carrier of this disease, which counted its deaths by thousands, was known. If he could be exterminated, the malady could be checked. General William Crawford Gorgas now came upon the scene. He made war upon the mosquito. He cleaned out his breeding places — the gutters, cesspools and places of filth. In ninety days there was not a case of yellow fever in the city. And, mind you, for two hundred years this island had not been free from the plague of the yellow jack.

Walter Reed and his associates had won a great victory. His dream had come true. Too bad that he could not live longer to enjoy his well-earned laurels. Within two years, the hero of the yellow jack died in an operation for appendicitis. But we can never forget his great service, nor the heroism of his valiant comrades.

General William Crawford Gorgas

I HAVE just mentioned General Gorgas. I am sure you will want to know more about him.

Like many another lad, Gorgas, when a boy, dreamed of being a soldier. His father had been a soldier and had graduated from West Point. Young Gorgas, too, wanted to go to West Point. It would seem that the son of a West Point man should have been able to get the necessary appointment. But in those days such appointments were wholly a matter of politics. Gorgas did not have sufficient

influence. The elder Gorgas had served in the Mexican War and later in the Confederate Army during the Civil War.

Young Gorgas had grown up in a military atmosphere. Some of the most stirring events of the war between the states were vivid memories. Born at Mobile, Alabama, in 1854, he passed his early years in one of those delightful old Southern mansions, nestled amid great oak and cedar trees. Forced to abandon their beautiful home, Gorgas and his mother fled first to Richmond and later to Baltimore. As he watched the great conflict, how he wished that he were old enough to fight! The son of a dashing officer at the front and of a mother in whose veins coursed the blood of a proud Southern ancestry could not have felt otherwise.

Then came the end of the war, and Gorgas' father found himself without an occupation. Soon, however, he became president of the University of the South at Sewanee, Tennessee. There, in a home of culture and refinement, the future leader in a great battle with disease obtained his college training. Following his graduation in 1875, he studied law for a year in New Orleans, but decided to become a doctor. Going to New York, he entered Bellevue Hospital Medical College, where he remained until 1880, when he obtained his commission as a surgeon in the United States Army. Though it was not to be as an officer of the line, his dream had in part been realized.

Like Reed, Gorgas served an apprenticeship at various army posts of the West. At length, he was sent to Fort Brown, Texas, where more than two thousand soldiers were sick with yellow fever. Contrary to orders, this in-

quisitive young surgeon undertook to dissect the body of a victim of yellow fever. Detected, he was sent as punishment to the yellow fever wards. There, he caught the disease, and almost died from its effects. Having recovered, however, he never again needed to fear the yellow jack, for it comes but once to the same individual.

When the war with Spain came, Gorgas, now promoted to the rank of Major, was made chief sanitary officer of the city of Havana, with orders to free this tropical city of disease. He it was who carried out the orders of General Wood to clean the city. And such a job as he did! Streets which had not been uncovered for decades were brought to light. Heaps of rubbish and garbage, rotting in the tropic sun, were carted away. Stagnant pools were drained. Mud and filth disappeared as by magic. Dead animals were buried. Stables were cleaned. Houses were invaded. In spite of ridicule and opposition, Gorgas did a wonderfully thorough piece of work.

"Now," thought this apostle of cleanliness, "yellow fever will disappear."

But, to his dismay, it only increased. The cleaner the city became, the more yellow fever seemed to ravage it. Officers and medical men alike were baffled. It was at this point that Major Reed and his associates came upon the scene.

Now let us have a word about this convicted member of the mosquito family. He has been given the scientific name of *stegomyia* and turns out to be a beautiful black insect, with silver white markings and long delicate wings. He breeds in stagnant water, never flies to any great distance from it and likes to live in houses, where he may

stay for many weeks. It is the female which carries the disease, and only then if it bites a yellow fever patient within the first three days of the attack. Even so, from twelve to fourteen days must pass before the mosquito becomes dangerous. But when this point is reached this spreader of disease for fifty-seven days will infect people whom it bites. These are facts resulting from the work of Major Reed and his followers.

Again, Gorgas was called upon to clean the city. This time he must make it a mosquitoless city. The natives grumbled and laughed at him, but he made them obey his orders. His officers and men went into every street, house and stable. Every conceivable breeding place for these mosquitos was sought out and thoroughly disinfected. Over pools of water, a film of kerosene was spread. This killed the larvae. House drains, puddles and cesspools were inspected. Houses containing yellow fever patients were tightly screened, so no mosquito could get inside. Within three months, so thoroughly was this job done, mosquitos simply disappeared from Havana, and with them, as we have already seen, went yellow fever.

The world sat up and rubbed its eyes, amazed at the result. It seemed like such a simple thing to do. Still, it required genius to solve the problem.

Major Gorgas now became a marked man. A still larger task lay ahead. Yellow fever had driven the French from the Panama Canal Zone. The United States was to undertake the great project. Yellow fever must be banished. Major Gorgas was asked to do for a tropical jungle what he had done in Havana. He must kill the mosquitos in a strip of land ten miles wide and fifty miles long. It

was a stupendous undertaking. Added to this, his superiors, not even General Goethals, appreciated its magnitude or sympathized with him and his methods. With the memory of Havana fresh in their minds, this is difficult to understand.

But, by the same tactics as those employed in Havana, Gorgas won the battle and made possible the digging of the Canal. He poured his very life into this great task. His enthusiasm knew no bounds. He inspired his men with his own fiery spirit. Today, the whole world knows that even the genius of a Goethals would have been powerless to dig the Canal without the victory won by Gorgas.

In recognition of his great service, Gorgas was made Surgeon-General of the United States Army, with the rank of Major General. Universities and foreign countries honored him with degrees and medals; England gave him the Harbin Gold Medal for "Services to Mankind."

And so the boy who wished to be a soldier had his wish fulfilled. Dying in 1920, he sleeps today in the national cemetery at Arlington.

Hideyo Noguchi

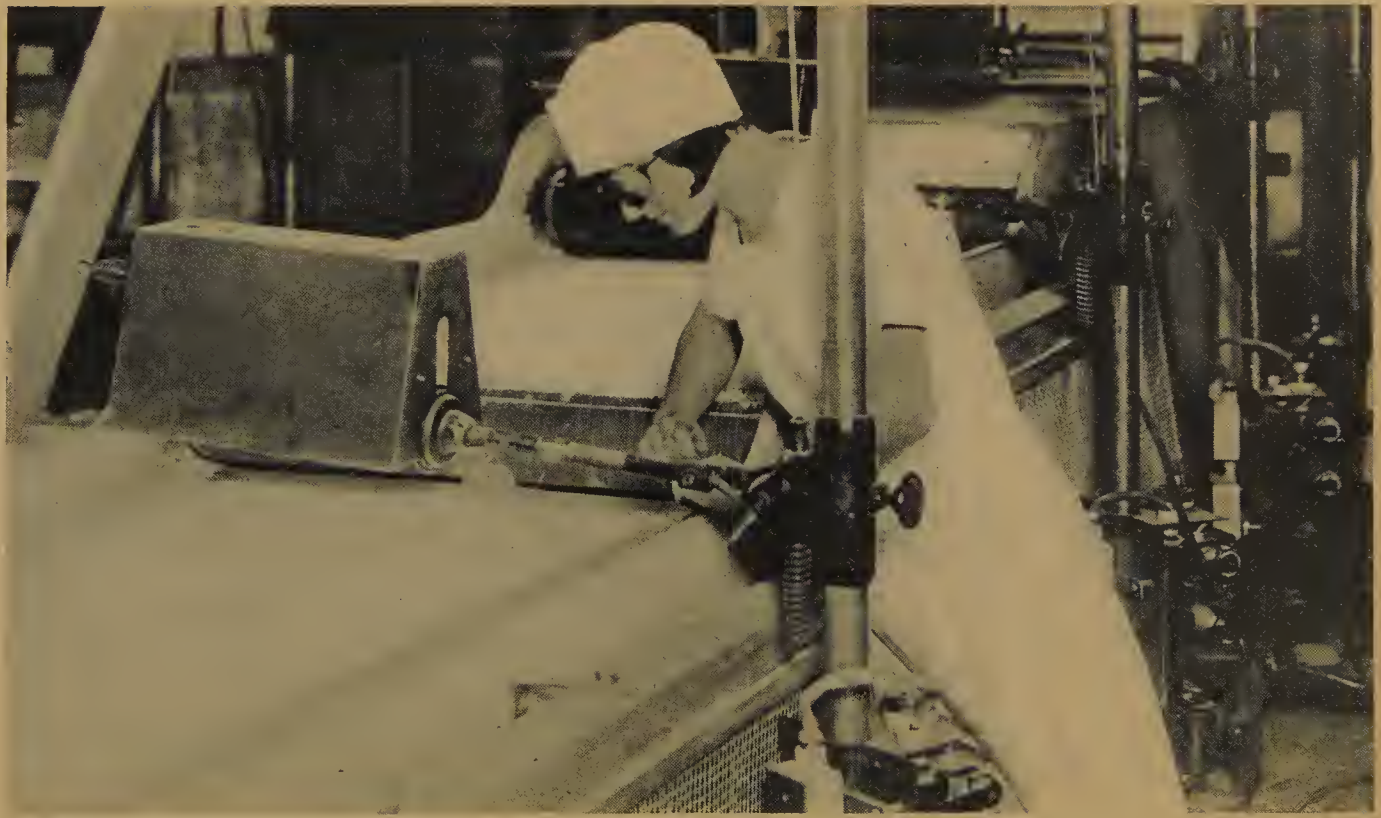
To BRING this story of the battle with yellow fever down to date, I must tell you of the great Japanese bacteriologist, Dr. Hideyo Noguchi. Let me say that a bacteriologist is a scientist who studies bacteria, those minute plant-like organisms frequently called microbes and in many instances causing disease.

Courtesy of the United States Public Health Service

Major Walter Reed

Surgeon Joseph Goldberger

General William Crawford Gorgas



Courtesy of the General Electric Company

Raying cereals with ultra-violet light to give them greater health-building properties

Although Dr. Noguchi was born in Japan in 1876, his great work as a scientist was done in this country as a member of the staff of the Rockefeller Institute. He worked on many diseases and was known the world over as one of the greatest leaders in the fight for human life. But we shall remember him most for his work on yellow fever. Why, you shall presently know.

In 1918, Dr. Noguchi went to South America to study the American form of yellow fever. You must remember that while Reed and his comrades had discovered the carrier of the disease, no yellow fever microbe had been found. Without this knowledge and the preparation of a successful vaccine, such as is used in the treatment of diphtheria, there could be no cure. A person who might get yellow fever would be in just as much danger of dying as in the old days when the *stegomyia* mosquito was at large. The purpose of Dr. Noguchi's South American visit was to discover the yellow fever germ. And he succeeded. He also prepared a vaccine and serum, which were quite successful in staying the disease if they were used immediately. War upon the mosquito and the use of Dr. Noguchi's discoveries practically stamped out yellow fever from the Western Hemisphere. This was the crowning achievement of a great victory.

Still, yellow fever persisted on the west coast of Africa. It began to be suspected that the African form of the disease was different from that in America. For many years, the Rockefeller Institute had kept a staff of laboratory workers at Lagos, in Nigeria. In South America, Dr. Noguchi had at last succeeded in giving the disease to monkeys and guinea pigs, something thought impos-

sible in the early stages of the fight. But for a long time this could not be done in Africa. Then, Dr. Adrian Stokes, a British scientist, succeeded, but fell a victim to the disease himself and died.

The opening up of a continent seemed to depend upon winning this final victory in the contest with the yellow jack. Dr. Noguchi knew more about the disease than any other living scientist. And so in the autumn of 1927 he sailed for Africa. His purpose was to discover whether the disease in Africa differed from that in America. If so, he wished to find the particular microbe causing it and prepare a poison to kill him.

As you probably know, this brave man became ill with the disease himself and died. This occurred in May 1928. While sick unto death, he insisted that samples of his own blood should be used in the study of the disease. To the last minute he fought for science and his fellowmen. Whether or not he succeeded is not yet known. His associates are continuing the work he began, and as soon as possible the results will be given to the world.

It seems certain that in the near future this story of victory and tragedy will end in the complete conquest of the long-dreaded yellow jack.

A Prophet of Health

If I were to ask you about Dr. Joseph Goldberger and what he did, I wonder how many of you could give an account of the disease known as pellagra and what he did to check it. But first let us hear about this man himself, the prophet of a new day in Dixie Land.

Dr. Goldberger was born in Central Europe, the son of Jewish parents. When six years old, he came with them to this country. His home was on the famous East Side in New York, where his father kept a grocery store. Like many another boy, he grew up in that swarming hive of humanity. It was decided early by Joseph's parents and his brothers that he should go to school. When ready, he entered the College of the City of New York.

Joseph's ambition was to be a mining engineer. I imagine that the wild life of such an occupation appealed to his youthful fancy. But one day a friend induced him to attend a lecture by Dr. Austin Flint. Spellbound, he listened to this master of physiology tell of the human heart and observed the heart of an animal shown as illustration. This event changed his mind and the whole course of his life. Eight years of hard study and preparation followed. Then he became a member of the United States Public Health and Marine Hospital Service.

Dr. Goldberger became an expert bacteriologist, the same field in which Noguchi distinguished himself. In particular, he studied certain diseases which trouble the countries just outside the tropics. Once he nearly lost his life from typhus. He got the disease in showing how this plague can be transmitted to monkeys. Lice which had fattened on sick Mexicans were allowed to bite the experimental monkeys. In some way, they bit Goldberger too.

One day in 1914, Dr. Goldberger received orders from Washington to go to the South and take charge of the campaign being waged against pellagra. At that time no one knew the cause of this malady which every year

counted its death toll in thousands. Its symptoms were plain enough, and its awful effects were seen on every hand. The victims became afflicted with sore mouths, and a rash broke out which looked like a mild sunburn. Gradually, this rash changed to a form of sores resembling leprosy in appearance. Sometimes these poor creatures became insane. A third or more of them, wherever the disease appeared, were sure to die. This was the situation when Dr. Goldberger arrived in the South land.

So rapidly did this red scourge sometimes spread that many doctors believed it contagious. They fumigated and quarantined and often created a near-panic with fear and dread. But the chief foe was ignorance, a foe which Goldberger, at the cost of his own life, was to banish.

Now, Dr. Goldberger did not do the usual thing in his investigations. He did not buy rabbits and guinea pigs. He did not try to discover whether there might be some treacherous microbe which was spreading the disease. Instead, he went among the sick and suffering ones of those poverty-stricken towns and asked questions by the score about this red plague. He talked with doctors and farmers and employers of labor. And he read all that he could find on the science of the disease. He studied the symptoms of these afflicted folks and learned to spot a pellagra victim on sight.

Gradually, one big fact began to stand out in his mind. These pellagrins, as they are called, were all poor. The disease almost never appeared among the rich and well-to-do people. What was the reason? If the disease were contagious, as many believed, it should afflict all alike. "Surely," thought Goldberger, "there must be something

about the living conditions of these poor whites which brings on the trouble."

Goldberger began to suspect that the diet, the food people ate or the lack of the right kind of food, gave the explanation. He hinted this to doctors and nurses. But no one would believe him. That was too simple. There was something far more mysterious about this malady. Nothing short of a microbe with a high sounding name would do. He must be discovered, sentenced and executed in public.

Goldberger continued his observations and at length began an experiment. He obtained permission from the trustees of an orphanage to supply, at Government expense, plenty of fresh meat, milk, eggs and vegetables to the boys and girls living there. It was a delightful experiment for the youngsters, and how they thrived on it! Almost by magic, pellagra disappeared. Children who but a short time before had been sick, weak and listless, now bubbled over with vim and energy. Goldberger had made a discovery. Proper food would cure and prevent pellagra.

Still, this was not enough. Would a diet lacking these nourishing foods cause pellagra? There was only one way to tell? Experiments must be made, and they must be made on human subjects. But who should they be? I do not think any of you would want to be the objects of such an experiment. No Lazears, Carrolls, Kessengers or Morans offered themselves to Dr. Goldberger. But he applied to the Governor of Mississippi for some convicts from the State prison farm. The Governor granted the request, promising liberty to the convicts at the end of the

experiment. Twelve men were selected, and the test was to last not more than six months.

Week after week and month after month passed, but still, although these men became sick and weak, there were no signs of pellagra. The skin rash did not appear. It began to seem as though Goldberger had won only half a victory. Then, one day his assistant discovered on a number of the men the peculiar butterfly-shaped markings of the red rash. There could no longer be any doubt. When the diet lacks certain necessary foods, pellagra will appear. Restore these foods, and the disease vanishes.

The poor whites of the South, during a considerable portion of the year, live on a diet known as the three M's. It consists of meat, meal and molasses. The meat is usually salt pork. Now, this kind of a diet lacks what the chemist calls protein. Without it, pellagra, which is really a form of starvation, results.

By injecting fresh blood drawn from pellagra patients into his own veins and those of others of his staff, Dr. Goldberger demonstrated that pellagra is not "catching."

And then, Goldberger made another discovery. He found that ordinary yeast acts like magic in curing pellagra. Two ounces of dried yeast a day will bring victims with the sentence of death upon them back to health and strength. An ounce and a half of yeast a day, even with a diet of the three M's, will ward off the disease.

What is the explanation? Of course, you have all heard of vitamins. They are mysterious chemical substances contained in minute quantities in many foods and necessary to health. Our grandfathers never suspected their existence, but they would have died without them.

For lack of fresh vegetables, sailors often get a disease known as scurvy. Certain vitamins are missing from their diet. Absence of a vitamin, called vitamin D, causes rickets in children. Well, yeast contains a certain vitamin factor known as PP, and it is this which cures pellagra.

I said that Dr. Goldberger lost his life in this fight against pellagra. In it he contracted a disease known as anæmia, a weakened condition in which the patient loses strength and energy. Medical science could not restore him to health. And so this man who had pointed the way to health for thousands of others died early in 1929.

But do not imagine that the South has been freed overnight from this scourge. Many can not afford the nourishing foods, and yeast is new. Among indifferent and often ignorant people, it takes time to teach the better way. Still, the new knowledge is bound to win, and the memory of Goldberger will remain for many a day.

Putting the Sun to Work

Of course, the sun always works for us. Many of you know that all the energy we have on this planet comes from the sun. Even coal is the crystallized sunshine of a former geologic age. In those marvelous chemical laboratories in the living cells of green leaves, the energy of sunlight causes the carbon dioxide breathed in from the air to unite with the water from the roots to form the woody fiber of the plant. This woody fiber is the raw material from which Nature makes coal.

Just now, however, I am thinking of another use of sunlight. It is one of the great scientific discoveries of

this twentieth century. The story takes us to the University of Wisconsin and beyond that to a farm in the northern part of the state. There, a generation ago, was born a lad with a yearning to know things and the genius and the patience to search them out. He graduated from the state university and later studied abroad. For nearly twenty years, he has been a teacher and what we call a research worker at the university. A research worker is one who makes new discoveries about Nature and her laws. All the progress of the world is built upon such discoveries. Where should we be today, had not someone gained the mastery of fire, discovered the expansive force of steam and unravelled the mysteries of electricity? Even the caveman in learning to chip flints, make clothes from the skins of animals and fashion utensils from clay was a researcher.

But what of this discovery about sunlight? And you want to know, too, the name of this Wisconsin lad with a bent for science. Harry Steenbock is the boy's name, now a college professor past forty, and the discovery has to do with those mysterious vitamins of which we have just heard in connection with Goldberger's work.

I wonder if any of you have ever had to take cod liver oil? If so, you know what horrid tasting stuff it is. You, too, have had a most unpleasant introduction to one of these famous vitamins. Probably, the doctor or your parents told you that this medicine would build you up and prevent colds, and possibly ward off pneumonia. Some of you may have had rickets, or a tendency in that direction, and you took cod liver oil in the dark, cloudy months when the sun is low in the heavens, to put more

lime in your bones and make them stronger. The fishermen of Newfoundland and Labrador have used this oil as long as can be remembered, and they are a wonderfully healthy people.

Now, cod liver oil will do all this, but the reason why was largely a mystery until a short time ago. It is known today that this oil, obtained from the livers of the famous cod, contains two vitamins, called A and D. In all, six vitamins are known at the present time. Vitamin A promotes growth. This is what enables your food to build your body and make it strong. And I am sure we are all happy to know that other foods than cod liver oil contain this necessary vitamin. For instance, milk and butter are rich in it.

Upon vitamin D hangs another story. Lack of it causes rickets in children and "weak legs" in animals. You know that the element calcium is one of the chief mineral substances which our bones must have. But sometimes the diet may be rich in calcium and yet the bones will not take it up. But it has been known for a long time that there are two cures for rickets — cod liver oil and sunlight.

It is vitamin D in cod liver oil which turns the scale, and scientists now believe that sunlight produces this vitamin in the skin. Be that as it may, the skin contains a substance known as cholesterol, and sunlight energizes, or stimulates, this in such a way as to enable the bones to take up the necessary amount of calcium.

Before I tell you of the part played by Professor Steenbock in this story of discovery, let me give you a bit of good news. It has recently been discovered that a substance called ergosterol, when exposed to what we call

ultra-violet light, is very powerful in preventing rickets. The dose, however, is exceedingly small, for an ounce of ergosterol will do as much as six tons of cod liver oil.

When scientists discovered that sunlight will cure rickets, they began to ask what part of the rays of the sun performs this miracle. For you know that sunlight can be broken up by a glass prism or the raindrops into the colors of the spectrum. Before long it became known that the ultra-violet rays are the health-giving ones. These are invisible rays, lying outside the violet which we see when we let light pass through a three-cornered piece of glass and make a color pattern on the wall. Although we can not see them, there are many ways of knowing that these rays exist. If I say that they consist of shorter wave lengths than any of the colors that we see, some of you will know what I mean.

Now Steenbock comes to the front. For sixteen years, he experimented with diets for sick rats and animals and used sunlight and ultra-violet rays in curing them of rickets. He became one of the greatest experts in this country in the study of this disease.

One day he made a happy discovery. He kept his rats in cages with wire screens for floor. The droppings of the animals and their food would necessarily cling somewhat to this screen floor. A report from England stating that an empty rat jar which had been exposed to ultra-violet light would thereafter prevent rickets led Steenbock to try an experiment. This story sounded queer. Steenbock wished to test it. To do so, he emptied one of his cages of its inmates and exposed the wire screen to these rays. Of course, he kept the rats locked in another room while

he did it. Sure enough, sick rats put into this cage got well.

But, and here was the clue, clean screening which had never been used as the floor for a rat cage, although exposed to these rays indefinitely had no effect in curing rats of rickets. In some way these ultra-violet rays had changed those minute particles of food clinging to the used screening. Furthermore, when fresh food was put on the floor of the cage, this vitalized food mixed with it, giving the rats just the element necessary to make them well. There was no other explanation.

And this discovery led Steenbock to a still greater one. First, however, let me pause to tell you that along with all of this work on rickets had gone the invention of lamps for producing ultra-violet rays in our laboratories and homes. And let me also say that these rays can do great injury when ignorantly used. They should never be employed except under the direction of an experienced physician.

Now, for the big discovery. Steenbock found that all sorts of foods, when bathed, or irradiated as the scientist says, with ultra-violet light, will obtain these health-giving properties. In some mysterious way, they vitalize the food, possibly giving to it this vitamin D. When Steenbock fed such energized food to his sick rats, almost by magic they got well. And what could be done for sick rats by this method could also be done for sick people.

You know now why this story took us to the University of Wisconsin and to the home of a farmer lad who became a great scientist. Professor Steenbock has been offered large sums of money by manufacturers of food for the

commercial use of his discovery. But he has refused them all. He has patented it, however, and given his rights to the Wisconsin Alumni Research Foundation, where it will be used wholly for the public good.

All this man asks for himself is the privilege of continuing his researches that he may add still more to our store of knowledge.

A Great Surgeon

THOUSANDS of soldiers in the Great War owe their lives to the wonderful skill of a brilliant French surgeon, who for many years has been the most distinguished member on the staff of the Rockefeller Institute for Medical Research. His name is Alexis Carrel. Even before the war, in 1912, he had won the Nobel Prize for the greatest advance in the field of medicine during that year. Although born and educated in France, Dr. Carrel has lived and worked so long in this country that we claim him as one of our greatest Americans.

Let me tell you first of what is probably Dr. Carrel's most important achievement in saving life. We know now, since the discoveries of Pasteur and Lord Lister, that a wound must be kept clean. If it is not, air-borne germs enter and blood poisoning frequently results. In all previous wars, many thousands of lives were lost because doctors and surgeons did not have this knowledge. In the first place, before the work of Pasteur they did not even know the existence of these disease-producing germs. And before the discoveries and experiments of Lord Lister they did not know the use of antiseptics in cleansing

wounds. Antiseptic sounds like a big word. Let us examine it. *Anti,* as you know, means against, and *septic* means poison. So we see that an antiseptic is a substance which destroys poison, usually the germs which cause disease.

In the war of olden times, the wounded were simply left to get well if they could or die in agony. Even in our Civil War and in the Franco-Prussian War, the losses from blood poisoning were frightfully high. In earlier wars, boiling oil or a white-hot iron were used to cauterize, or sear over, wounds. When blood poisoning resulted, amputation of a limb was often necessary. In the days before the use of ether and chloroform was known, such operations were scenes of the most awful torture. But now this has all been changed.

Now for Dr. Carrel's discovery. In those fateful months of 1914, when the fertile fields and peaceful villages of Belgium and France were transformed into terrible scenes of warfare, Dr. Carrel returned to his native land and gave his services, not to destroy life, but to save it.

Dr. H. D. Dakin, an English surgeon, had found that a solution of hypochlorite of lime is a strong antiseptic. It kills the germs, but does no harm to the tissues themselves. The substance which kills is the element chlorine. This is released from the hypochlorite. Many of you have made it in gaseous form in the laboratory and know how poisonous it is.

Still, the success of such an antiseptic depends largely upon a way of using it. And that is what Dr. Carrel invented. He devised a way to keep the wound thoroughly moistened with the cleansing solution all the while. It

consisted of an ingenious arrangement of tubes and drains. At frequent intervals, fresh solution was applied. The bacteria did not have a chance. They were killed before they could begin to work and multiply. In a week or little more at the longest, the most frightful wounds were made entirely clean, or sterile, as the surgeon says.

Then, Nature did the work of healing. Nature always does this. All we can do is to keep the wound clean — free from dirt and bacteria. The life forces of the body itself rebuild the tissues and repair the damage. This method, known as the Carrel-Dakin treatment, produced astonishing results. Such rapid recovery from festering wounds and infected tissues had never before been seen. Cures were made which would have amazed the surgeons of a half century before. Surgeons everywhere during those dark years of war were profoundly grateful to Dr. Dakin and Dr. Carrel for this great boon. And in these days of peace, it is no less beneficial.

Important as this discovery is, it is as a surgeon that Dr. Carrel has done his great work. He has shown his fellow workers how to take the cut ends of an artery and "suture," or join, them together so that they will grow and restore the artery as it was before. This method has revolutionized the surgery of blood vessels. He is able to take an organ from one animal and place it in another, making it live and function. In one instance, the kidney of one cat was transplanted into the body of another. He once astonished his fellow surgeons by showing that a part of an artery which has been removed can be replaced with a part of a vein, the ends knitting together perfectly.

Most interesting have been Dr. Carrel's experiments in

keeping tissues and organs alive after removal from the body. In some instances, this has been done for weeks and months. An artery which had been kept alive in this way for many weeks was transplanted into an animal, where it continued to live and function. And he has found it possible to take tissues from one kind of an animal, say a dog, and make them do duty in another kind of animal, such as a cat.

What is the purpose of such experiments? I hope none of you imagine that they are done for entertainment. Only by such work can medical men learn how to perform the marvelous feats of modern surgery. Its object is the preservation of human life. Before surgeons could transfer living bone, someone by experiment had to discover the way. Many a face has been restored practically to normal because of this new knowledge. And in it all Dr. Carrel has been one of the greatest and most inspiring leaders.

The close of the war found Dr. Carrel back in his laboratory at the Rockefeller Institute. He is not an old man, and we may confidently expect that still greater things will be born of his ingenious brain and skillful hands.

Dr. Carrel has told us that, could we have a great research laboratory, where scientists of all kinds could work together, attacking the stronghold of disease from every angle, some of our most difficult problems might be speedily solved. It will cost millions of dollars to establish such a laboratory. Congress has been considering the project for several years. Let us hope that this dream of a great surgeon may yet come true.

A Group of Pathfinders

I AM not going to tell you much about this "group of pathfinders," pioneers in a new field of medical research. That is, I shall not relate their early experiences — where they were born, went to school and how they came to be great doctors and scientists. But we can not leave this battle with disease and not know something about the endocrine, or ductless glands.

Barbarous names, these are, I know, but we shall have to get familiar with them. I fancy I hear some of you saying, "What is a ductless gland anyway? I never heard of one before." Well, most people do not know that they have any such organs, and even physicians did not suspect their existence until a little more than a half century ago. However, occasionally a surgeon would purposely or carelessly remove some innocent looking little piece of tissue, and to his bewilderment discover that his patient promptly died or became afflicted with some hideous malady. That is the price which some unfortunate victims have to pay for medical progress. In this case, this bit of tissue happened to be one of these ductless glands, sometimes called the "glands of destiny."

I presume many of you have read of the deadly poison with which the natives of the Upper Amazon tip their arrows. So violent is this poison that the slightest scratch will kill the biggest animal in a few minutes. Well, this poison is obtained from the ductless gland of a certain toad.

Before we go any further, we must know what is meant by "ductless." Most glands of the body pour their secre-

tions into the system by means of tube-like ducts. These glands, however, have no ducts. Their secretions are discharged directly from the gland into the blood-stream.

Now, what about this deadly poison from the ductless gland of a toad? This powerfully active chemical substance is called adrenalin. The glands from which it comes are the adrenals, or suprarenal bodies. They are located, one just above either kidney. But, so energetic is this drug that our system requires for health only one part in a billion parts of blood. In times of emergency, it is secreted in larger quantity. Then it stimulates the whole system to action. When aroused by sudden fear or anger, this is what excites the nerves, steels the muscles, quickens the heart beat, opens wide the eyes and makes the hair stand on end. It makes the timid brave and sometimes nerves the coward to deeds of heroism.

One other thing I must tell you about the secretions of these ductless glands. Their marvelous effects are due to the presence of exceedingly active chemical principles, called hormones. And here is where we must introduce the first of this group of pathfinders. The scientist saw that if he could separate any particular hormone and learn how to prepare it in the laboratory, he would place a powerful weapon in the hands of the physician.

The first important explorer in this field was Dr. John J. Abel, professor at Johns Hopkins University. And he is still at work. Although a great discoverer, he is too busy to know it. But his fellow chemists a short time ago awarded him a famous medal, known as the Willard Gibbs Medal, in honor of his great services.

A generation ago, Dr. Abel separated the first hormone.

It was the deadly adrenalin of the suprarenal bodies. He also learned how to manufacture it, so that it may now be obtained at any drug store.

You may wonder what the use of so powerful a drug may be. Well, for one thing it enables the surgeon to perform bloodless operations. When applied to a bleeding wound, it stops the flow of blood instantly. Introduced into the blood in minute quantity, it stimulates and strengthens the action of the heart. This makes it of great value in cases of pneumonia. It has actually been known to stimulate into action a heart that has ceased to beat. Adrenalin will often enable a greatly weakened or aged person to withstand the shock of an operation. It will instantly check the spasms of acute bronchial asthma.

Do you not think we are right in calling Dr. Abel, who has made all this possible, a great discoverer and a pathfinder?

There is another ductless gland which means much to your well being. It is called the thyroid and is found just above the windpipe close to the larynx. When it does not work properly, a child gets a form of idiocy which the doctors call cretinism. It becomes dull-witted, slow to learn and coarse featured, wholly unlike healthy boys and girls. In older people, when this gland goes on strike, the disease makes a person weak, feeble-minded and useless.

Now comes the second pathfinder. In 1918, Dr. E. C. Kendall, a chemist of the famous Mayo Clinic at Rochester, Minnesota, succeeded in separating the active chemical principle in this gland. It is called thyroxin. Very

minute doses of it will cure children and grown people of this feeble-mindedness. There is just one difficulty. The substance is more precious than diamonds. Only a little of it is to be had. But not long ago two chemists in London showed how to make it in the laboratory. We hope soon to have it in larger quantity. And just think of what it will mean when we are able to shed into many a darkened mind the light of reason!

Let us for a few minutes take an easy lesson in physiology. Every boy and girl likes sugar. But probably few of you ever stop to think that sugar and similar foods like starch are fuel for your body. They supply a large part of the energy which keeps you going. Sugar is as necessary to your life as gasoline to a motor car. Some of you have already learned how sugar is changed in the liver into a form of starch, called glycogen. You know, too, that the starch is stored there for future use. As the body needs it, this starch is changed back into sugar and delivered to the blood stream. There it combines with oxygen to form heat and bodily energy.

But how does the liver know when to change this glycogen into sugar and release it to the blood? That is why I am telling you of this activity now. A wonderful messenger, called insulin, "presses the button" and gives the signal. Now this insulin, of which many of you have heard and some of you probably take, is a hormone. It is secreted by the pancreatic gland. So long as this gland is in health, all goes well. When it is out of order, people have a lingering disease known as diabetes. The liberation of sugar from the liver is so rapid that the tissues can not use it. The fuel so badly needed is wasted. The body

does not get the benefit of it. It is just the same as though you had a large leak in the gas tank of your car. The motor would soon come to a stop. And so does the bodily motor.

Here come the pathfinders again. This time, there are three of them — Dr. F. G. Banting, his assistant, Mr. Best, and Dr. J. J. R. MacLeod. It was in the laboratory of Dr. MacLeod at Toronto University, Canada, and with his help and advice that Dr. Banting and Mr. Best worked. Although these men did not know that such a hormone as insulin exists, they believed there must be some such regulator. There was only one way to tell. They must experiment. Using the pancreatic glands of healthy dogs, they began. Others were working on the same problem, but this trio at the Canadian university won the race. In 1922, word went round the world that the active principle of the pancreatic gland had been discovered. Dr. Banting had led in the work, and for this great triumph he was awarded the Nobel Prize in medicine for that year. However, he promptly shared the $40,000 received with his associates, Mr. Best and Dr. MacLeod.

Dr. Abel has since prepared insulin in pure crystalline form. He is now working on a method for its manufacture.

Because of these discoveries, thousands, both young and old, who would otherwise be on the highway to certain death, are living happy, useful lives. This is one of the two or three most important medical discoveries in half a century.

There are other ductless glands no less important, and other pathfinders. Scientists have really only begun to

experiment in this fascinating field. When in the future you hear more about these glands, I want you to know what they are and how much their healthy action means to everyone.

You have learned a little about this great battle with disease. But scientists tell us that what is known about health and its preservation is far less than what is unknown. Here is the most important field for scientific study. The great scourges of mankind, such as cancer, pneumonia, influenza, tuberculosis, and heart disease must be conquered. Perhaps, some of you may help in the years to come.

CHAPTER X

GREAT ENGINEERS

A GENERATION ago, one thought of an engineer as that picturesque and romantic individual who presided over the destinies of a steam locomotive. I think this hero of an earlier time used to capture the imaginations of more boys than any other object of boyhood ambitions. Even yet few of us do not at times long to sit in the cab of a locomotive with hand on the throttle and feel the thrill that must come from being master over such a mighty giant. Fascinating stories, too, could be told of the daring and courage of these faithful servants who for a century and more have been guiding our trains over the vast system of highways which cover the land with a network of steel. But it is engineers of another sort of whom I wish to tell you now.

For nearly forty years, the study of engineering in our colleges and universities has been eagerly followed by hundreds of young men. I have no doubt that some of you are planning to be engineers. Still, engineering is not new. The builders of the pyramids were wonderful engineers. There were canals before men began to write history, and it took engineers to build them. Bridges were among the earliest of engineering triumphs. Archimedes, that old Greek who one day said to King Hiero,

"If I had a place to stand and a lever long enough, I would move the earth," was the first of modern engineers. You have read, too, of the engines of war which he built to protect the city of Syracuse from Roman invasion.

Pretty soon men began to discover the laws governing natural forces. They learned to use these laws and forces to their own advantage. Before this they had been "rule-of-thumb" engineers. But when they began to understand the principles of machines, they became scientific engineers. It is about these real engineers that I am going to tell you now. They have remade the surface of the earth and brought forth its resources. Now, as I write, I can hear from the street outside the steady hum and roar of compressed-air drills. This and scores of other applications of modern science are the tools of the engineer. With them he has re-created the world.

Suppose we begin with the greatest engineering triumph in modern times, possibly the greatest in all history. I do not think you will have much difficulty in guessing that I mean the digging of the Panama Canal. Back of that huge ditch, which connects two oceans and divides a continent, stands a great personality. And it is men, nerved to action under the influence of a great leader, plus the discoveries and inventions of science, who bring to pass the engineering achievements at which the world marvels today. This big human engineer who built the canal after others had failed died so recently that he almost seems still to be among us. You know his name, George W. Goethals.

When Colonel Goethals arrived in the Canal Zone, an army engineer sent by President Roosevelt to accomplish

what both French and other American engineers had failed to do, there was much gossip as to what sort of man he might be. Of course, they expected him to appear with shoulder straps, brass buttons, and military decorations. It was thought that all workmen and subordinates would have to stand at attention and salute whenever he should appear. They did not at all relish the idea of military discipline. Despite the tropic heat, Goethals found himself in a decidedly cool and hostile atmosphere.

Then came the great surprise. Goethals did not come in uniform, and he did not wear one at any time while he was there. His interest was first in men as human beings, and then in the work they were doing. The pouring of concrete, the squealing of donkey engines, digging great cuts, laying foundations, building locks, ridding the region of disease — these and a multitude of other tasks were soon discovered to be the chief concerns of this czar of the Canal Zone. He established his home and office close to the brink of the famous Culebra Cut. The noise of the steam shovels from the bottom of the cut constantly floated in through his office window. The sound of the drills seemed as music in his ears. No salutes were required, but the men soon were saluting, for they came to love the man and to have unbounded enthusiasm for the work. He seemed to fire every man with an irrepressible energy.

That is why the canal was dug in one year less than the specified time and for nearly ten million dollars less than the estimated cost. Colonel Goethals divided the Zone into three sections, the Atlantic, the Pacific, and the Central. Over each, he placed a superintendent. Then he

set each section to working against the others in a spirit of friendly rivalry. It worked like magic.

Goethals knew how to handle men. Going among them, he would say to one gang, "Shovel No. 400 took out 15,000 cubic yards last week. Can't you beat that?" "You bet," would come the answer. "We'll show you." And they did.

To the boss of a dam building gang, he would say, "Mr. Jones, the water is rising. Are you going to get that dam done in time?" "Sure, Colonel. We must."

It is said that Goethals one morning came upon a foreman who had been at work since midnight trying to repair the damage from a big slide of earth.

"Well, how is everything this morning?" asked the Colonel. "Fine, Colonel. It buried that steam shovel over there and tipped over two batteries of drills and covered all the tracks through the cut but one, but everything's fine. We're diggin'."

That is the kind of optimism with which this human dynamo inspired his men. Obstacles seemed to become as mere trifles in his presence. He never became discouraged. When as much dirt was sliding into Culebra Cut every night as could be carried out the next day, he would say cheerfully, "Well, it might be worse."

I have referred to Colonel Goethals as a czar, for that is what he was. His authority was absolute. His word was law. But he was a kind-hearted and benevolent czar.

Soon after his arrival, he established a Sunday morning court, where anyone could come with any grievance he might have. He never refused to listen to anyone whose cause was just. "Tell the Colonel" came to be the

answer to a multitude of troubles. To him came discharged workmen, women with home troubles, men at odds with their bosses, families disgruntled over their housing accommodations, homesick boys, invalids complaining of hospital treatment and many more. All received a hearing.

And Goethals did not forget them. As he went through the Canal Zone from day to day, he was continually asking after this man's sick boy, the word that one had received from his father in the States, or of the health of another. And his interest was not sham. It was genuine and kindly. The men knew that his heart beat in sympathy with theirs. It was the humanness of the man that dug the canal.

Now, what of the preparation this man had for his great work? His parents were Hollanders, tracing their ancestry back to the Crusaders. He was born in Brooklyn, N. Y., in 1858. At eleven, he was an errand boy and at fourteen he was keeping books for a produce merchant nights after school and Saturdays. For a time, he attended New York University. His first purpose was to be a doctor, but later he decided upon West Point provided he could secure an appointment. This he did through a political leader of New York known as "Sunset" Cox. In 1876, he entered the military academy.

At West Point, Goethals made a brilliant record. He was a leader among his classmates, being elected president of his class; in scholarship, he graduated second in a class of fifty-four; and in his last year he was chosen by his superiors as one of the four captains of the cadet corps.

Because he was one of the highest in rank, he was

chosen for the engineering corps. This was in 1880. For nearly twenty years, he followed the quiet life of an army engineer in peace time. He built fortifications and bridges, dug canals, constructed locks and dams, and learned to handle men. During the Spanish War, he was disappointed not to be sent to Cuba. He wanted real military service. Instead, he went to Porto Rico as an army engineer. Nothing of importance happened there, and his great opportunity seemed to have passed.

However, when President Roosevelt came to select an engineer to carry the "American Suez" to a successful conclusion, his choice fell on Goethals. But it did not do so by chance. He had made a name for himself and proved his great ability. General Mackenzie, at that time chief of the United States Corps of Engineers, said, when it became known that an army engineer was to be chosen to dig the canal, "We all immediately thought of Goethals."

It was a tremendous undertaking. The French under De Lesseps, the engineer who built the Suez Canal, had spent ten years and $260,000,000, besides losing thousands of lives without succeeding. Two American engineers had not made much progress. In Goethals, Roosevelt found the man who was big enough to handle the task.

The canal today is one of the world's great highways of peaceful commerce. Although intended as a means of military defense, its greatest usefulness is the promotion of friendly intercourse among nations. It has proved of vast importance to the republics of South America, to our own Pacific Coast States, and to Europe and the Orient. This canal is General Goethals' great monument.

I have referred to this leader of men repeatedly as "Colonel." Although he later became a general, to those who knew and loved him, and there are thousands such, he will always be "the Colonel."

The Builders of Brooklyn Bridge

ALTHOUGH the Panama Canal is the biggest engineering accomplishment on this continent, the Brooklyn Bridge is the most beautiful. Its graceful lines have been the admiration of engineers, architects, and the general public ever since its completion in 1883. For several years there was scarcely a week in which I did not cross Brooklyn Bridge at least once and often a number of times. A delightful old gentleman of my acquaintance, Dr. George H. Berns, was the first civilian to ride a horse over the bridge. He had received an official call from Manhattan and, mounting one of his fine horses, he took the shortest route. As he reached the New York side, the toll keeper told him of the unique distinction which fortune had brought to him. And that day marked the first time when the East River could thus be crossed. Always before, ferryboats, battling with ice in the winter and at all times with the tide, made the connection between the two cities. It is said that a person in Albany could often make the trip to New York more quickly than a business man could go from his Brooklyn home to his Manhattan office.

When the bridge was first proposed in the 'fifties of the last century, the woods were full of skeptics. Engineers and civilians alike united in saying that the thing could not be done. No bridge so long had ever been built.

Furthermore, the people did not need a bridge. Ferry-boats were good enough. The cost would be too great. All this and much more appeared in the newspapers and was heard in conversation. But talk of a wonderful structure spanning the East River did not stop. Gradually, the idea grew. There were those who believed that such a dream might come true. At last the man appeared who had the supreme faith and the masterful skill and ability to perform the task. I want to tell you about this man and his equally famous son.

In June 1806, a boy was born in Mülhausen, Germany, described as

A sleepy town, where under the same wheel
The same old rut is deepened year by year.

This boy's name was John Augustus Roebling. Though his father was slow and plodding, quite content with the sleepy atmosphere of his native town, the mother was a woman of great force and intelligence. When she discovered that her youngest child, John Augustus, displayed unusual ability, she determined that he should receive the best education possible. Every sacrifice was made, and at length the boy found himself a student in the Royal University of Berlin. There, under famous masters, he studied architecture, engineering, languages, and philosophy. He soon became a fluent master of French and English in addition to his native tongue.

Becoming convinced that the land of opportunity was in the New World, he set sail for America in the year 1831. His mother, to whom he owed the beginnings of a successful life, saw him off and provided a small sum

of money with which to start in the new country. As he waved her good-bye, he little knew that before he should reach the other side a fatal illness was to take her away.

Arrived in America, Roebling decided to become a farmer and purchased about 7,000 acres of land not far from the frontier town of Pittsburgh, Pennsylvania. However, it did not take him long to discover that he was not intended for farming. But ready to hand was an occupation in which he was very shortly to prove himself a master. There were in this pioneer country land to be surveyed, canals to be dug, and dams and bridges to be built. Soon his services were in great demand. This was the very work for which he had prepared himself in the university. And it was work that he loved to do. That is the important thing. One must like the task he is doing. Then it becomes play.

Canals were the great means of transportation in those early days. Still, canals could not cross mountains. But the difficulty was met by the use of inclined planes. The boats were built in sections. When a boat came to a mountain, it was taken apart. Each part was hoisted to the mountain top over a huge inclined plane. It was lowered down the other side over a similar plane. The work of raising or lowering was done by means of a giant windlass. An immense hemp rope attached to the section of the boat was wound or unwound on the drum of this windlass. It was this operation which offered Roebling the first great opportunity of his life.

These ropes were big and clumsy and not very strong. They soon wore out. How could Roebling improve

them? One day he recalled that a German in his native town had made a wire rope. He determined to try his hand at this business. Soon he had a twisted wire rope, not more than a quarter the size of the hemp ropes and vastly stronger. It was immediately put to use for all sorts of purposes, and the name of Roebling began to be famous.

In those days, it was often necessary to carry a canal over a river. That is, a water-filled aqueduct had to be constructed to float the boats over the water flowing beneath. It occurred to Roebling that an aqueduct suspended from cables made of his wire rope would be much better and more lasting than those then in use. Of course, his idea was opposed. Like many other new things, few believed in it. But at length his opportunity came. He received a commission to build such an aqueduct over the Allegheny River, near Pittsburgh.

Roebling knew his reputation was at stake. If he succeeded, he would be a famous engineer. If he failed, he would be threatened with ruin. The work was a tremendous success, and Roebling was soon building many such water bridges. On his Pennsylvania farm, he built mills in which he drew the wire and manufactured the rope for his construction work. His idea was rapidly growing into a large business.

In 1848, on the invitation of Peter Cooper, who had iron foundries at Trenton, New Jersey, Roebling moved his plant there. It required then seven days to make a journey which we now cover in almost as many hours. There, he began an enterprise which was soon to be employing thousands of men and in time was to make the

name of John A. Roebling and Sons known throughout the world.

From suspension aqueducts to suspension bridges was but a step. Again, no one believed that a bridge suspended by great cables of wire was practicable or possible. Certainly, the idea of spanning Niagara Gorge and its thundering waters was foolishness itself. But this was exactly what Roebling now proposed to do. In 1851, he flew a kite to carry his first wire across. Four years later, the first train passed over the bridge. And this was the world's first suspension bridge. John Roebling was a pioneer. In the years from 1856 to 1867, he spanned the Ohio with a similar bridge at Cincinnati. Then came what was to be the crowning achievement of his life.

The work at Cincinnati was scarcely complete when Roebling was appointed engineer to undertake the building of the Brooklyn Bridge. Indeed, it was largely because of his unconquerable belief that such a bridge was possible that men decided upon the bold attempt. With Roebling's leadership courage came.

However, the work was scarcely begun when the pioneer bridge builder met with a serious accident. His foot was crushed in a ferry slip, resulting in lockjaw, from which he died.

Now comes the story of his son, Colonel Washington A. Roebling. The younger Roebling was already a skillful engineer with many important accomplishments to his credit. Following his graduation from the Rensselaer Polytechnic Institute in 1857, he became assistant to his father in bridge construction. On the day Fort Sumter

was bombarded, he enlisted in the army. He served throughout the war, carrying out many important engineering undertakings for the Union cause. For gallantry at Gettysburg, he was commissioned a colonel.

At the close of the war, he returned to the building of bridges. He was as familiar with the plans for the Brooklyn Bridge as was his father. When the elder Roebling died, he was immediately appointed as engineer in his place. With all the energy of young manhood and the inspiration coming from a great task, he threw himself into the work.

To support the tall towers from which the cables are suspended, enormous boxes, called caissons, were sunk mouth-downward for considerable distances into the river bottom. To accomplish this, men were compelled to work beneath the caissons at air pressures two or three times as great as that at the surface. Such air pressures sometimes cause a distressing malady known as "caisson disease."

Colonel Roebling soon became a victim of this dread disease. He had insisted upon working in the caissons with his men. So much depended upon his presence. The slightest error might mean disaster with the loss of hundreds of lives and millions of dollars. But partial paralysis put an end to his direct supervision of the work. Still, he would not give up. He moved his home to Brooklyn Heights, where from a wheel chair on the roof he could watch the work with field glasses. He gave directions to the smallest detail, and then from his vantage-point saw them carried out. For thirteen years, this hero of a peace-time battle whose mind was still as keen as ever,

planned and commanded the execution of the great work. At length, he saw it crowned with success.

In the great celebration which marked the opening of the bridge, Mrs. Roebling, who had been the constant companion and helper of her husband, drove the first horse across the magnificent structure. In doing so, she noted that there was no vibration. It seemed as staunch as the everlasting hills. And so it has been ever since. At last, those who for years had looked up at the slow but patient work of construction and had often wondered if it would ever be completed beheld this monument to the Roeblings, father and son, fashioned in masonry and steel.

For forty-three years following that great day, Colonel Roebling lived to enjoy the satisfaction which comes from a great task well done. For many years, he was the president of the company bearing his name. His hobby was the collection of minerals, of which he had one of the largest and rarest collections ever made. His son has given these to the Smithsonian Institution with an endowment of $150,000 to provide for their care and the purchase of additional specimens.

Truly, John A. Roebling and his distinguished son were leaders of men.

A Discoverer of Precious Metals

Engineers are of many sorts. I want to tell you now of an engineer who has made this old earth deliver more of her ages-old store of precious metals than any other man who ever lived. In South Africa, together with Lord

Cecil Rhodes he rediscovered a 3000-year-old gold mine which now produces $20,000,000 of the yellow metal a year. And he located other gold mines in that rich continent. He has become famous the world over for his wide knowledge of ore formations and his ability to tell where precious metals may be found.

This man is John Hays Hammond. His father was a West Point graduate, who served in the Mexican War. His mother was a sister of a famous Texas ranger, John Coffee Hays, who became the first sheriff of San Francisco. It was natural that the spirit of adventure should flow in his veins. Even as a boy of fifteen, he and a younger brother set out to explore the Yosemite Valley, riding on their horses sometimes fifty miles a day, camping out at night and living the rough life of mountaineers. When their parents, after a three weeks' search, located them, they were 500 miles from home in the neighboring state of Nevada.

Hammond was born in San Francisco, in 1855, when the gold excitement was still strong. He had seen gold and watched miners at work from his earliest childhood. No wonder he decided to become a mining engineer. But there were no colleges in California in those days, and his father sent him back East to be educated. He first attended a preparatory school in New Haven, Connecticut, and then entered the Sheffield Scientific School of Yale University. From Yale, he went to the Royal School of Mines at Freiberg, Germany, returning to this country in 1879.

The first job of this youthful engineer was with Senator Hearst of California, for whom he made tests which re-

sulted in the investment of many millions of dollars. The following year, he entered the service of the United States Geological Survey. Here, he received a wonderful training. Visits to mines, work in the ore mills, making tests, locating new territory, adding to the world's wealth of precious metals — all this fascinated the young engineer whose love of mining was a part of his very being.

Shortly after, a trip to Mexico in the interest of a mining company led to many thrilling encounters with brigands and Indians and much hardship. In the end, he put the property on a paying basis and brought out many hundreds of pounds of silver metal.

South America next lured him. High in the Andes, between the headwaters of the Orinoco and the Amazon, he learned that the Indians were uncovering gold. For a time lost in the jungle with only two native guides, going for three days without food, living upon some wild beans resembling coffee, crossing country which had no trails and following creeks toward their sources, Hammond at length found himself in a little mining community far from civilization. On this excursion, too, he met with cannibals, but they offered him no harm. To young Hammond, this was life.

Back in his own country, as manager of mining properties in the famous Cœur d'Alene district of Idaho, Hammond had many severe struggles with striking miners. On one occasion, mounting to the engineer's seat in the cab of a locomotive, he pulled a trainload of workmen through a danger zone, every mile of which threatened him with peril from dynamite or strikers' bullets. By the

time he was forty he had won the name of being one of the most daring and reliable mining experts in the world.

The owner of large mines in South Africa now sent for Hammond. Soon, however, he found himself in the employ of Cecil Rhodes, empire builder of that new land of vast natural resources. Rhodes asked him to name his salary, and Hammond asked for $100,000 a year and a share in the profits. This was a very profitable bargain for Rhodes, for the American engineer through new methods of mining added vastly to his wealth.

In the events leading to the Boer War, Hammond had a large part. On one occasion, he was captured by the Boers and sentenced to death. Only the devotion of his wife and the confidence of President Kruger in the sincerity of his motives saved his life.

Upon his return to this country in 1900, Hammond continued his work for large mining interests in this and other lands. Twice, in the days before the Revolution, he was engaged to investigate the mineral resources of the Russian Government. In Mexico and California, he has engineered large irrigation projects. He was for a time Professor of Mining Engineering at Yale, and has built for the university a large mining laboratory, for his pursuit of the precious metals has made him a wealthy man. And he has served his country in many ways.

This man who as a boy dreamed of being a great mining engineer has seen his dream come true. One could hardly wish for greater success in the thing he chooses to do. And the world is still big with opportunity.

A Youthful Engineer

WHAT boy or girl does not admire the story of youthful triumphs? But imagine yourself, not yet twenty-three, suddenly sent to a far land by a large industrial organization in a foreign capital and placed in charge of vast mining interests valued at millions of dollars with hundreds of workers under your direction, some of them engineers with twice your years and many times your experience. Yet that was the situation in which Bert Hoover, now President Herbert C. Hoover, found himself in the middle 'nineties of the last century. He was in Australia, a strange country, sent there because of demonstrated ability as a mining engineer in the Sierras of his adopted state, California. So youthful was he that he had felt compelled to grow a mustache and beard to hide the boyishness of his face and mouth. What you are interested to know, however, is how Bert Hoover came to be in this position of distinction and power. Let us have the story.

I do not need to tell you that Herbert Hoover is a Quaker. He came from a long line of Quaker ancestors. His great-great-great-grandfather, Andrew Hoover, had come from Holland and settled in Maryland in 1740. There he built a log cabin on a small piece of land and became skillful with his axe and gun and a thrifty tiller of the soil. But he was not altogether happy in his new home. The exactions of his church galled him. He had come to America for religious liberty, and he had not found it. One day, from a traveler stopping at his cabin, he learned of the Society of Friends. A small community had been established on Huwarra Creek in North Caro-

lina. There, Andrew and his wife, Margaret, moved, and from that day to this the Hoovers have been Quakers.

In that picturesque era of pioneering in a new land, a time of thrilling adventure and much hardship, John, the son of Andrew, left his father's home and, crossing the mountains with two of his brothers and his young son, Jesse, settled on the fertile plains of the Ohio Valley. Later, the grandson of this sturdy frontiersman pushed still farther westward and became a pioneer settler of Iowa.

Hoover's mother, Huldah Minthorn, had come from English folk, who settled in Connecticut even earlier than did Andrew Hoover in Maryland. Her people had been scholars with a love of books and education. They, too, were Quakers, and Huldah had come with her father and mother to live in West Branch, Iowa. There, she married Jesse Hoover, grandson of the first by that name. In that Quaker village, in 1874, Herbert Hoover began life. Little did anyone dream in those early years that Bert Hoover would some day travel to far corners of the earth, becoming a man of power and wealth, the friend of kings and peasants alike, and at length President of the United States.

Hoover's boyhood passed like that of any other healthy boy in a country village. His father was a dealer in machinery of all sorts, particularly of implements and machines for the farm. Never was he too busy to explain to the youngsters who frequently gathered in his big building how a machine worked, what made an engine go, or the advantages of some new device. On Sundays, the lad went with the other boys and girls and his elders

to sit through a long and tedious service in the Friends' meeting house. Thus the early years passed.

In the early winter of his sixth year, Bert's father was taken with a severe cold. He and his older brother went to stay with an uncle. They had not been there long when one night they were aroused from a sound sleep to be told that their father was much worse. Hurriedly they dressed and were driven across country as rapidly as two horses could carry them. When Bert saw his mother, he knew, from the quiet look on her face, that his father had gone. Bravely they all met the changed situation, and his mother determined to save all she could from the sale of the property for the education of the boys. Little did Bert and Tad know that in three years more their mother would be gone too, and they would be left orphans, to be cared for by relatives.

Bert Hoover, now nine years old, went to live with an uncle and aunt living on a farm in Cedar County, Iowa. He was to help with the work as much as he could, but, being yet young, he was to pay out of the small estate left him by his mother for part of his board. A kindly old gentleman, who had been made his guardian, gave him a little book, in which to keep his accounts.

For two years he worked on the farm in summer and walked two miles with books and lunch-pail to school in winter. Then came a letter from an Uncle John Minthorn in Oregon offering to take "Bertie" to live with him in a new country. This uncle was the principal of an academy in a little settlement named Newberg, and said his nephew could be a student there. Earnestly the matter was considered by his elders. Then Bert himself was

asked what he wished to do. The lure of a new country and the academy was strong. Furthermore, he had come to dislike farming. Reluctant as he was to leave his friends, he answered, "I think I had better go."

For five days and nights he traveled in a day coach with a neighbor, who was going West, across the plains and over the mountains. At length he arrived in Portland, a hustling city of fifty thousand. The railroad could carry him no farther. There he took a river boat on the Willamette, which bore him by dense forests, the like of which he had never before seen. Late in the afternoon, the boat arrived at Wynooska Landing, where his Uncle John met him. Once more he was in a community of Friends, in a pioneer village.

Although his uncle and aunt were kind and interested in his best welfare, the stern discipline and numerous duties proved irksome, and Bert often found himself in a state of rebellion. He longed for a real friend and companion. Then one Sunday morning his heart stood still with gladness and surprise. His brother Tad had come from Iowa to be with him. No longer would the days and nights seem dreary and lonely. For the first time in many a day he was to have a sympathetic comrade.

When he was thirteen, Uncle John moved to Salem and began a real estate business with several partners. Bert was given his choice of school or a job in the office. He decided upon the latter. He seemed to have been born for this kind of work. Soon he had mastered the details of the business. In a score of ways he was useful. He opened the office, swept the floors, dusted the desks, and opened the mail. Then he arranged the window displays,

showing the products of the fertile agricultural lands which the company sold. But he did more. He filed the correspondence, blue prints, and important papers. The men came to depend upon him for remembering the details of every transaction. He answered questions, ran errands, multigraphed letters, and made maps of farm lands. In his evenings, he studied to prepare for college.

Hoover was now sixteen, but far older in experience than his years would indicate. Leland Stanford, Jr., University was to open that autumn in Palo Alto, California. Entrance examinations were to be held in Portland. He decided to take them; but could he pass? His schooling had been scanty and frequently interrupted. Although he failed in geometry and English, he made a wonderful impression upon Professor Swain, who conducted the tests, and was told to study during the summer and take the examinations again. He did so, and the opening of Stanford found Hoover among the students. Another corner had been turned in his career.

A part of the small legacy left him by his father and mother still remained, but not enough for his four years in college. He must work, and he did. Geology became his favorite study. Even as a lad he had been fond of collecting queer specimens of rocks. He and Dr. Branner, the geology professor, were soon firm friends. An agency for a laundry was enabling him to pay his way.

The first football game of the new university was an event. With the team and scores of other enthusiastic students, Hoover made the trip to San Francisco and out to the Olympic Club grounds, where the game was to be

played. And Stanford won. It was glorious. He received a thrill such as he had never experienced before.

Back to Palo Alto and more work, oceans of it. His first summer vacation was spent in Arkansas, making a relief map of the state. He now lived in Romero Hall, a student club, which he had helped to organize. His junior year began with the great business panic of '93. Scores of banks had failed, but two hundred dollars of his funds remained untouched, and he had just received the joyful news that his Arkansas relief map had won a prize at the World's Fair in Chicago. Hoover, too, was becoming known among his fellows as a man with the capacity to organize and direct. They wanted him for treasurer of the athletic committee, the most important position in the gift of the student body. Reluctantly, he consented to run, and was elected by a good majority. This meant more work, but it had to be done. He put the athletic organization on a business basis, and himself received a training which was to be invaluable in a few short years to come.

Commencement Day came and went. Immediately, he entered the service of the United States Geological Survey, working as a geologist in the Sierras, whose granite heights and rugged scenery he had come to love. By the middle of October, the Survey job was ended. It had only been for the summer. Hoover found himself without money and nothing in sight to do. Mine superintendent after mine superintendent had turned him away. Brusk foremen had no time to talk with him. Then he found a job at two-fifty a day pushing a mine car. How his muscles ached at night and his nerves twitched!

Two months of this, and Hoover quit. The mining engineer at the plant said, "Why don't you try Louis Janin in San Francisco?" In the morning, he was on the train, bound for the city by the Golden Gate.

Louis Janin was a famous mining expert. Hardly daring to hope for anything at his hands, Hoover entered his office. Janin wanted to know his experience and asked for references. Hoover satisfied him, and in six weeks he had so demonstrated his ability that Janin sent him to New Mexico at a salary of thirty dollars a week and expenses. His job was to inspect sixty-three mines and report on them. Much depended upon his judgment. Banks often make investments of large sums on the strength of a mining engineer's opinion. Once he was convinced, Hoover stood his ground. In one important instance, where his report was doubted, other experts agreed with his recommendation. Janin made him resident engineer in New Mexico and increased his salary. At the same time, he received a letter offering him a position with the United States Geological Survey. He decided to continue as a mining engineer. This decision marked a turning-point in his career.

At the end of the summer, Hoover returned to San Francisco. Janin met him with praise for his work and a still bigger opportunity. The large mining firm of Bewick-Moering in London had asked him to recommend a young American mining engineer for a position in Australia. The salary was to be nine hundred and sixty pounds, almost five thousand dollars. Would Hoover take the job?

The firm wanted a man "thirty years old, with seventy-

five years' experience." They had big problems to handle. Hoover was only twenty-two and still boyish in appearance. It would be a post of great responsibility. He decided that the opportunity was too big to pass by. He accepted.

Now you have the story of how this youthful mining engineer happened to be in Australia with vast interests under his direction.

Arriving in this bleak and barren country by way of London and the Mediterranean, Hoover found the affairs of the company in utter chaos. He plunged into the work, concealing his youth as best he could and grateful for the daily growth of mustache and beard.

It would be a long story to tell of the trying weeks and months that followed. Hoover made good. He reorganized the mining properties; replaced inefficient subordinates; introduced American machines and methods; and gradually untangled the affairs of the company. Fortunes in England rested upon his decisions. He made enemies, but he did his duty, and he worked harder than anyone else. Bewick-Moering cabled their congratulations and made him a junior partner in the local branches of the organization. Eight offices were now under his control. By following his expert judgment, Hoover's superiors in London in one instance made a profit of a million and a half dollars. He had forgotten his youth. He was too busy with the big game of engineering.

Again Hoover was booked for promotion. The London office cabled him, offering to make him manager of its entire West Australian interests, or send him to China. He chose the latter and returned to California by way

of London to be married. Then with his bride, Lou Henry, he sailed for China.

Bewick-Moering had sent Hoover to China to enter into an agreement with Chang Yen Mao, Director General of Mines and Railways, for the reorganization and development of extensive mining interests. The red tape and endless delays of oriental pomp and ceremony sorely tried his impetuous spirit. This young man of twenty-four, too, was in a delicate position. He was more than the mere representative of the mining firm in London. In a sense, he was the ambassador of a nation interested in the development of great natural resources.

Finally, after weeks of tedious waiting, a trip to inspect the mines was arranged. He was appalled at what he found. He said, "There isn't one American miner in the Sierras who could not teach these people five centuries of mining!"

A host of problems, more difficult than any in Australia, faced the young mining engineer. And everywhere sluggish indifference, delay, or open opposition. Two years passed, and Hoover was master of the situation. He knew China's mines as no one else ever had. His plans were laid.

Then, almost over night, came the Boxer Rebellion, and the life of every foreigner in China was imperiled. Hoover and his young wife were in Tien-Tsin. The city was besieged. It was Hoover who organized the defense. He seized the food, planned a rationing system, commandeered wagons, set people to work, and put his men in charge. He directed the building of a barricade along the river front. Rifle bullets spit fire in the dusk and here

and there raised little clouds of dust. Artillery boomed in the distance. Buildings were struck; occasionally one tumbled in a heap of ruins; the dust of crumbling mortar filled the air.

At length came the great attack. Chinese cavalry charged the British guns. There were five thousand Allied troops in the city. The yellow army retreated in disorder, and General Nieh, its leader, committed suicide. Twelve hours later, reinforcements came — American, British, Japanese, Italian, German, and Russian troops. The danger was past.

In two weeks, Hoover sailed for London. In his pocket were contracts for the control of great mining properties. Bewick-Moering received him with enthusiasm, gave him fifty thousand dollars' worth of stock in a new company which was organized, and sent him back to China as general manager.

Difficulties beyond Hoover's control in the management of the properties arose, and he returned to London to be made a junior partner in the great firm of Bewick-Moering. He was now twenty-seven.

A year later, he found himself bankrupt. One of the firm's partners had involved the company for seven hundred thousand dollars. Hoover must begin again. He insisted that every dollar be paid. The newspapers gave him high praise for his unswerving honesty. Four years passed, and Bewick-Moering were on their feet again. Hoover had traveled the world over, organizing mining properties in Korea, Siberia, Burma, Australia, and elsewhere. His connections extended to the far ends of the earth. Young mining engineers everywhere had come

to depend upon him. His home in London was a meeting place for American travelers. In due time his fortune was repaired.

Eight years he remained with Bewick-Moering after the failure of 1902. He had hoped that he might retire and devote himself to some of the things he longed to do. But the lure of the big game was too strong. His obligations to great mining and financial interests could not be lightly dropped. The mining world needed him. He could not forsake it. And so he continued as a consulting mining engineer.

Then came 1914 and the World War. His business interests like a network covered the world. Citizens of every nation were stockholders in his companies. But business runs on credit, and credit suddenly disappeared. Everything was chaos. Travelers in Europe found themselves stranded, without funds. Travelers' checks and letters of credit were valueless. Ambassador Page in London appealed to Hoover for assistance in meeting the situation.

Immediately, he went to work to organize the American relief funds. He and his friends raised two hundred thousand dollars. The United States Government sent a quarter of a million more. The crisis was met. Hoover's wonderful genius for organization and his training in big affairs made him the man of the hour. More than ever his home became a place of refuge.

Close upon this came a cry from Belgium for help. The task was that of feeding seven million men, women, and children. Herbert Hoover was the man. Would he do it? A nation in distress looked to him. Ambassa-

dor Page, the Belgian delegation, and hundreds of others besought his aid.

With equal insistence another group begged that he would not desert them. Banking and mining interests needed him. Millions depended upon his judgment and direction.

Hoover asked for two days in which to think it over. He had reached another turning-point in his career. He decided to take the Belgian job, and without knowing it that decision was to make him President of the United States.

Of his work in Belgium, I do not need to tell you. Its imperishable record is inscribed in the hearts and memories of grateful millions of his fellowmen. Many thousands who were children during those dark years of war can never forget the great service which he performed and the self-sacrifice he made. And he handled hundreds of millions of dollars, sent to him from the four quarters of the globe and safe-guarded only by his personal integrity. That was sufficient. Not a dollar was misapplied, never a trust betrayed. Friend and foe alike honored him.

When America entered the war in April 1917, Hoover could no longer remain in Belgium. He, then, returned to the United States to become Director of the American Food Administration. The world will never know all that he did in the following months to insure the food supply and with it save the Allied cause. His was a big part in the victory that came.

For eight years, he was Secretary of Commerce in the cabinets of Presidents Harding and Coolidge. Now he is President.

Thus, the Quaker boy, who was left an orphan at nine, has demonstrated once more that the best aids to an honorable and successful life are character, ability, and hard work.

The Father of Telephone Engineering

One day in October 1921, my telephone in Brooklyn rang and someone said that General John J. Carty, Vice-president of the American Telephone and Telegraph Company, wished to see me at his office, 195 Broadway, New York. I was doing some writing on the telephone at that time, and so this request did not particularly surprise me.

When I went over, I discovered that General Carty wished to tell me something regarding the ceremonies in honor of the Unknown Soldier, which were to be observed at Arlington on Armistice Day of that year. There, I learned of the newly invented loud-speaking telephones which were to catch the voices and the music and the peals of guns at Arlington and amplify them for reverent thousands on either ocean-side.

Then, on Armistice Day I found myself in the old Madison Square Garden along with ten or twelve thousand other people. In the park outside and stretching away to the Flatiron Building in the distance, were twenty-five thousand more. A similar audience had gathered in San Francisco, while a hundred thousand were scattered over the slopes at Arlington. Through the loud-speaking telephones just mentioned, these vast audiences were made as one.

At a quarter of twelve, a clear rich voice began to speak. It seemed to come from somewhere in the Garden, but no speaker appeared on the platform. And then, too, the voice filled the immense auditorium as no individual unaided could do. At the same time, the thousands in the park outside and those in San Francisco and at Arlington were listening as well as we. Every word was clear and distinct. Not a sentence was lost. We heard as well as though we had been standing beside the casket of the Unknown Soldier at Arlington.

In imagination, we pictured the distant scene, with the City of Washington and the Potomac before us and the white marble colonnades of the amphitheatre glistening in the sunlight. We saw, too, the multitudes gathered to pay the nation's tribute to her historic dead. There were the foreign diplomats, the Justices of the Supreme Court, the Members of Congress, the Gold Star mothers, the hundreds of troops, and the silent thousands from the ordinary walks of life.

Presently, an orchestra struck up the strains of the national anthem, and we found it difficult to believe that the music was not originating in the Garden itself. The chaplain at Arlington read Scripture and offered prayer, and we listened as well as though we had been in our own churches. Then, the vast audiences in these three widely separated places joined in repeating together the Lord's Prayer and in singing America. This is by far the most impressive moment that I have ever experienced. I never again expect to witness anything half so awe-inspiring.

A hush fell on the vast assembly. Then the silence was broken by Secretary Weeks introducing President Hard-

ing. Rich and full, we heard his voice say, "We are met today to pay an impersonal tribute. The name of him whose body lies before us took flight with his imperishable soul. We know not whence he came, but only that his death marks him with the everlasting glory of an American dying for his country." As he pinned the Distinguished Service Cross to the casket, we heard the words, "Won in mortality to be worn in immortality." And so on to the sounding of taps and the echoing of the guns from the hillsides of Virginia.

Why have I told you this? Because General Carty is known as the "Father of Telephone Engineering," the branch of engineering which made possible this great triumph. The telephone today plays so big a part in our lives that it is difficult to believe that the art of telephone engineering is spanned by a single life. And General Carty is still a large part of this great system of communication.

John Carty was born in Cambridge, Massachusetts, in 1861, the son of Irish parents. He probably inherited his bent for engineering from his father, who was a gunmaker and expert mechanic. In particular, young Carty was interested in electricity, and that was at a time when many of the most notable triumphs in this field were hardly dreams. The telegraph had been in use for a generation, but the telephone was not placed on public exhibition until Carty was fifteen years old. Edison had not yet invented the electric lamp. Electric street cars were not even curiosities. Our great power plants and long-distance transmission lines, the bright white ways of our cities, and the electrochemical industries of modern

science, to say nothing of the radio, were all unknown. No one dreamed that electrical engineering would become so important in the big undertakings of the next half century. Without knowing it, Carty's interest in electricity was to make him a pioneer in this new conquest of Nature.

Of course, Carty went to school, and he was a good student. At the Cambridge Latin School, he prepared for Harvard University, but his eyes failed him, and he was compelled to abandon all thought of a higher education. However, he did not long remain idle. He had become fascinated with the apparatus he saw in the show windows of a shop kept by Thomas Hall of Cambridge. One day he saw a sign in the window, "Boy Wanted." Although Carty was then nineteen, he applied for the job, and received it.

Carty longed to get at that window of apparatus. At length, his chance came. He says, "I had rather hoped that the boss would come around and consult with me as to how to adjust the apparatus. But that was not it. He said: 'John, clean out that window. Everything is full of dust, and be careful and don't break anything.' So I cleaned it out. I swept out the place, cleaned about there, did errands, mixed battery solutions, and got a great deal of experience there in one way or another."

His next job was in a telephone exchange, where he became a "hello boy." Girls had not then become the rulers in these centers of communication. But let us not imagine that the telephone exchange in which Carty worked was anything like those of today. He says, "The little switchboards of that day were a good deal like the

automobiles of some years ago — one was likely to spend more time under the switchboard than sitting at it! In that way I learned a great deal about the arrangement and construction of switchboards."

This telephone job proved to be Carty's opportunity. He learned everything about switchboards, but more than that he learned how to improve them. Soon he became an expert and was later placed in charge of the switchboard department of the Western Electric Company.

But Carty's first great triumph came in another way. In that experimental period, telephoning was a different matter from what it is now. For one thing, a weird babble of underground noises played over the telephone circuits both night and day. Carty believed he could stop this annoyance. Until that time, the earth had been used for the return circuit, just as in telegraph lines. For the earth, Carty substituted a return wire. The result was like magic. This distracting confusion of noise immediately disappeared, and quiet has reigned ever since.

Carty now became a big factor in the development of the telephone. Theodore N. Vail, the general manager of the Bell company, brought him to New York and assigned him the task of putting the maze of overhead wires in cables running beneath the city streets. He did this at half the former cost of such work, and in record time. He invented the "bridging bell" too. This made possible the party line. With it, each subscriber could be rung without ringing any of the others at the same time.

Still, Carty's big triumphs were in the future. In 1915, under his leadership, transcontinental telephoning became a matter of history. Then, too, in that same year Carty's

engineers brought about the first great achievement in wireless telephony, radio we should call it now. At Mare Island, California, he was able to converse with Vail in New York as easily as though they had been in adjoining rooms. And the following day messages, that is the spoken voice carried by wireless waves, were picked up in Honolulu, 5,000 miles from the sending point. In the spring of 1921, he opened telephone communication by cable, wire, and wireless from Havana, Cuba, to Catalina Island, off the coast of California, a total distance of 5,500 miles.

During the war, Carty served in the Signal Corps, going to France, where he rose to the rank of Brigadier-General. He is still an able leader in the field of telephone engineering, which he founded nearly a half century ago.

The Builder of a Great Tunnel

I MUST tell you just a word about another great engineer. Every reader of this book has heard of the Holland Tunnel. Many of you have passed through it. Some of you know that it takes its name from Clifford Milburn Holland, the youthful engineer to whose energy and enthusiasm this connecting link between two states is due. Although he died before the completion of the work, it was done in accordance with his plans, and it was the inspiration of his example that carried it through.

Holland was a son of Massachusetts, being born at Somerset in 1883. Immediately following his graduation from Harvard in 1906, he went to New York to engage in the construction of tunnels for subways under the East

River. In eight years, he had become so thoroughly master of this kind of work that he was placed in charge of all the East River subway construction. Four of these tunnels will forever remain as witnesses to his engineering genius.

Men marveled at his complete mastery of every detail and the tremendous load of work which he could carry. More than this, he inspired his associates with his own courage and enthusiasm. They recognized in him a leader whom they were proud to follow. When it became necessary to choose an engineer to take charge of the building of the traffic tunnels beneath the Hudson to connect the States of New York and New Jersey, Holland stood forth from all others as the best qualified. Over the heads of older men and men of international renown, he was chosen. That the Commission chose wisely, all the world now knows.

To the deep sorrow of all connected with the undertaking, the task proved to be too great, not for Holland's keen brain, but for his physical strength. Just as the two sections of the tunnel from opposite sides of the river were being "holed through," death came. But the work had been so far advanced that its completion was only a matter of the routine carrying out of Holland's plans.

One of the great engineering feats of any time, this tunnel will stand as a perpetual monument to the ability and noble qualities of heart and soul of Clifford Milburn Holland.

CHAPTER XI

LEADERS IN BIG ENTERPRISES

THIS is often called the day of big business. As compared with the easy-going ways and simple life of our grandfathers, it is. Machines without end, motor cars, telephones, airplanes, and much more have changed the picture. Wants have multiplied. What used to be luxuries are now necessities. The production of goods of every description has increased enormously. And with it all has come what we call big business. There have been many leaders in this new era, but I want to tell you of four. We shall begin with Theodore N. Vail, a man who so recently left the scene that he even yet seems to be with us.

Of course, we first wish to know what sort of boy this man of big business was. Although his ancestors in this country were among the sturdy pioneers, settling first on Long Island and later in New Jersey, Theodore was born in Ohio in 1845. But he did not grow up there. When he was two years old, his father moved back to New Jersey, where he had a number of prominent relatives, influential in the affairs of the community and state. There, Theodore, or "Doe" as he was often called, passed his boyhood, one of a large family, in which

discipline was stern, luxuries few, and forms of pleasure simple and wholesome.

That he was a real boy, we know from the following incident. An older cousin living not far away had a garden in which he grew fine melons, of which he was very proud. Close by was a luxuriant bed of asparagus. Theodore and a friend used to hide in the asparagus, watching their chance to steal out and bring back a melon. It was a great mystery to their owner where the melons went. In the fall, however, when the asparagus was cut, the melon rinds told the story, and the culprits received their punishment.

Of course, this boy went to school, but when he had finished what we should now call high school, he felt that he should begin to earn some money. Few young men and women went to college in those days. His first job was that of clerk in a drug store. The store also contained a telegraph office, which proved to be far more interesting than standing behind the counter and running errands. He little knew then what a large place in his life the romance of the wires was to fill.

When he had been in the drug store about a year, he began the study of medicine in the office of an uncle, Doctor Quinby. Still, the lure of the wires was too strong, and after a few months he besought another uncle to get him a place in a telegraph office. As a result, he soon found himself in a Western Union office at Fortieth Street and Eleventh Avenue in New York.

We must not forget to mention that as a lad and throughout his young manhood, Vail was an enthusiastic baseball player, and usually the star on his own team.

Clean sport always played a big part in his life. Even in the days of big business, which were to come, he never lost his interest.

At the close of the Civil War, Theodore's father, Davis Vail, like many others, decided to move West. The country there was new. Land was then cheap. Opportunities were larger. He felt that in the big, open spaces of the prairie country his family would be better off. The journey was an event in the lives of all of them. Deep, seemingly endless woods, the immense, level fields of the Middle West, the big unkempt town of Chicago, the crossing of the Mississippi, the vast rolling country beyond — all made a profound impression. At length, they found themselves at Waterloo, Iowa, and nearby the Vails took up a claim and began the hard task of breaking the sod and building a home.

Although their claim was nine miles from the village, Theodore made frequent trips there and was soon a leading member of the baseball team. To him also fell the lot of plowing eighty acres of tough prairie sod and fitting it for the first sowing of wheat. He liked the life there, and he once said he was almost sorry he had ever left it.

During one winter, Vail taught school in a little one-room building on the prairie about three miles from home. Several times, when fierce blizzards swept the country, he and the pupils stayed in the schoolhouse overnight.

Still, Vail had come to dislike farming, and he did not care for teaching. He had learned telegraphy while in New York, and the wires once more beckoned to him. This was in 1868, when the Union Pacific, the first transcontinental line, was nearing completion. He applied

for a position and was given the "night trick" at Pinebluff, Wyoming. That was then a wild frontier country. There were hostile Indians in the neighborhood, and fights frequently occurred. Once, he and a brother, who had joined him, were on horseback on the plains when they found themselves face to face with a band of Indians. Turning about, they galloped toward the settlement, the Indians in pursuit. Soldiers from the fort, seeing them, rode to the rescue, and the Indians fled, but not until one of the soldiers had been killed.

Again Vail became dissatisfied. He wanted a position with a larger future. Some of his friends were in the railway mail service, and the prospects appealed to him. He little knew then what a large part of that service he was to become. Through his uncle, Isaac Quinby, he obtained an appointment and in 1869 was assigned to the run from Omaha to Wasatch. Over the rough, uneven roadbed, through a country still beset with Indians and buffaloes, he traveled back and forth. His salary was nine hundred dollars, and a little later it was raised to twelve hundred, regarded as big pay in those days.

Within a few months, Vail was given the run between Iowa City and Chicago, and in his spare time he studied law. What was more important, he studied mail routes and ways to improve the service. In those days, letters were often weeks and even months in reaching their destinations. Little sorting of mail was done on the trains. The railway post office car was hardly a dream. In fact, it was Vail who invented it. So valuable were his ideas that he was soon advanced to the position of chief clerk of the Union Pacific division. Then, he was called

to Washington, where he became assistant to the General Superintendent of the mail service of the entire country. His task was to develop his idea of the railroad distribution of mail on all lines. It was the biggest undertaking ever assigned to a postal assistant, but Vail did it well, so well that within four years he was made Assistant General Superintendent and a little later General Superintendent, in full charge of the mails of the nation.

Still, Vail was not to remain long in Washington. A bigger task was calling him. He was placed in command of the postal service in 1876, the very year that Alexander Graham Bell demonstrated his newly invented telephone at the Centennial Exposition in Philadelphia. But to keep the record straight, let us see what had preceded this event.

Many of you know that Bell was a young Scotsman who had come to this country to recover his health. For several generations, his family had been interested in the science of human speech. Bell himself was an elocutionist and, like his father before him, a teacher of deaf mutes. He had also acquired a little knowledge of electricity. He knew that the German physicist Helmholtz had vibrated tuning forks by means of electromagnets. This seemed most remarkable to Bell. He thought about it a great deal. One day, he said, " If I can make a deaf mute talk, I can make iron talk." In that moment, the idea of the telephone was born. Soon, it had driven every other thought from his mind.

I do not need to tell you here the oft-repeated story of Bell's early struggles. We shall, however, wish to review one or two of the leading events. On June 2, 1875, oc-

curred the first. It was a hot, sultry day, and things were going badly for Bell and his assistant, Thomas Watson, in the stuffy attic of Williams' Electric Shop in Boston, where they had their laboratory. For many weeks, they had been trying to make their crude line carry some sort of message. Suddenly, Bell came dashing into the room where Watson was, his eyes blazing. "What did you do then? Don't change anything. Let me see!" he exclaimed. A feeble sound had passed over the wires, and Bell's keen ear had caught it. That was the beginning of success.

Yet, Bell and Watson worked for nine months more before they made their telephone talk. Then, on March 10, 1876, Watson heard Bell say, "Mr. Watson, please come here. I want you." That was the first telephone message. Watson had been on an upper floor, and the wires had extended to Bell three flights below. Progress now became rapid, and in a few weeks Bell had his apparatus ready for a public demonstration. The Centennial Exposition at Philadelphia, just opening, afforded the opportunity, and as all the world now knows the young inventor scored his first great triumph.

Still, there was a long road to travel from that triumph to commercial success. People could not see that the telephone was of any practical value. It was simply a toy and of scientific interest only. The telegraph, which was still an object of awe and wonder, seemed to serve every need of communication. Who would ever want to talk over a wire anyway? The baby telephone received a very cool welcome in the world of practical affairs. It needed

a business executive, a man of big ideas, to sell it to the public. In Theodore N. Vail, Bell and his associates found that man.

Most people called Vail crazy to give up one of the most important positions in the government service to assist a struggling inventor who was without funds or public favor. But this was characteristic of Vail. He had what we call vision. He was one of the half dozen men of the time who could see the future possibilities of the telephone. And it was due to his courage and ability more than anything else that the telephone industry forged to success.

When Vail, in 1878, came up from Washington to take charge of the telephone forces, he found an empty treasury, Bell's financial backer, Thomas Sanders, completely discouraged, Bell himself sick in the hospital, and a noisy group of claimants trying to rob him of the fruits of his invention. The situation seemed almost hopeless, and it would have been to a man of less energy and optimism than the former chief of the mails possessed. Immediately, he began to organize new companies to take care of the telephone interests in various parts of the country. He persuaded his friends to buy stock. He employed lawyers to defend Bell's rights in the courts. He looked after the manufacture of telephones. He established exchanges and built new lines. And all the while he struggled against the threat of bankruptcy. So low were the finances at one time that a supply house in New York refused the company credit for a bill of goods amounting to only a few dollars. It now happens that the building of the American Telephone and Telegraph Company on

Broadway covers the very spot occupied by that supply house.

Long after, Vail was asked if he did not feel discouraged in those days, and he replied, "If I did, I never let anybody know it."

The biggest obstacle to Vail and his forces at that time was the Western Union Telegraph Company. This powerful organization sought to monopolize the telephone business as well. Ignoring Bell's rights, they were also establishing telephone lines, and for a time they had the advantage. Edison had invented for the telegraph company a transmitter much superior to Bell's. The Bell subscribers clamored for something as good. Then the tide turned somewhat. Fortune began to smile upon Vail and his comrades. When everything looked so dark, Francis Blake came forward with a new transmitter as good as Edison's, which he offered to the Bell company in exchange for stock. It was a godsend, for it made the Bell service as good as that of the Western Union. Furthermore, Vail's lawyers beat the Western Union in the courts. Bell's patent was upheld, and his powerful rival withdrew from the field.

The result was like magic. The Bell stock shot up like a sky-rocket. Before long it was selling at a thousand dollars a share, and Bell and his partners found themselves wealthy men. This included Vail, for he had invested heavily in the telephone stock. His vision and remarkable business ability had made him a millionaire. He could now surround himself with the luxuries which by nature he had always craved. In Roxbury, near Boston, he secured the ownership of a beautiful home, where he went

to live with Mrs. Vail and their young son. There, too, he brought his father and mother from the Iowa farm, and it was a great source of pleasure to be able to provide them with the comforts and luxuries which their strenuous life had often denied them. He filled the big house, too, with works of art and other treasures brought from far and near. He also indulged his love for horses, and in those busy but happy years he might often be seen driving through the country "four-in-hand."

For a half dozen years, Vail continued to be the life of the telephone enterprise. In 1885, he was made president of the company. He extended the lines; he established new exchanges; in New York, he began the work of putting the wires in cables underground; and he built the foundations of the business so well that prosperity did not forsake it. Still, the burden of responsibility became too great, and in 1887 he resigned. In the meantime, he had acquired a large estate near Lyndonville, Vermont. He named it "Speedwell Farms" after the ancestral home in New Jersey, and there he retired for a time to the life of a country gentleman, varying it all with an occasional prolonged trip abroad.

A man whose life from early years had been associated with big business could not long remain inactive. Leisure was pleasant for a time, but it could not become Vail's chief occupation. And so he found himself deeply interested in a venture to provide Boston with a central heating system. However, it was a failure, and he soon discovered that the bulk of his large fortune had disappeared in the crash. Speedwell Farms remained, and some stock in a Colorado gold mine, which he had re-

garded as worthless, began to pay dividends. One or two other enterprises in which he was interested brought some returns, making it possible to continue the quiet life in the country.

Once more the spirit of business adventure lured Vail from his home among the Vermont hills. This time it was to South America. A friend told him of the big opportunities waiting in Argentina. His was always the spirit of the pioneer. From boyhood, he had longed to visit these lands to the south. Now, he did so and for a number of years engaged in the development of water-power sites in Argentina and in the building of electric traction lines. These undertakings proved to be highly profitable, and in their operation he rebuilt his fortune. But he did not stay in South America. His own country beckoned to him, and he returned to Speedwell Farms.

Vail had now been absent from the telephone business for many years, but he could not forget it. It had been the first big undertaking of his life, and its success was a matter of pride. Following his resignation from the presidency, the company had not grown as it should. It had prospered, but not as in the early years. Its management had not been as active as under the leadership of Vail. Then came the business panic of 1907 and with it a crisis in the affairs of the company. Vail had just sold his interests in South America and had returned to his own country, as he thought, to retire to his Vermont farm. But this was not to be. The telephone company drafted him. He seemed to be the only man with the business experience, the ability and enterprise to pilot the affairs

of the company through the storm. And so he returned to New York to do the most enduring work of his life.

The big things in the telephone world were done in this latter period of Vail's leadership — things which are now a matter of history. In the period of his absence, the telephone lines had been extended to Chicago. Vail with the able assistance of his chief-engineer, General John J. Carty, now carried them to the Golden Gate. On that memorable January 25, 1915, Bell in New York and Watson in San Francisco conversed as easily as though they had been in adjoining rooms. Once more, Watson heard Bell say, "Mr. Watson, please come here. I want you." And Watson replied, "It would take a week now, Professor."

In that same year, too, wireless telephony was developed by the Bell engineers until the ether was carrying the human voice across the continent, halfway across the Pacific and from our eastern seaboard to Europe. The part that the telephone played in the Great War is now a part of history. And through it all, we see the guiding hand of Vail. This was the period of telephone expansion, the years of big achievement. Probably, the history of American enterprise offers no other example of such splendid growth under the direction of a single organization.

And since his death in 1920, Vail's spirit of leadership has been marching on. In the following year, Havana, Cuba, was linked by telephone with Catalina Island, off the coast of Southern California. New York today talks with London and other cities of the Continent. Television is a demonstrated success, even television in colors.

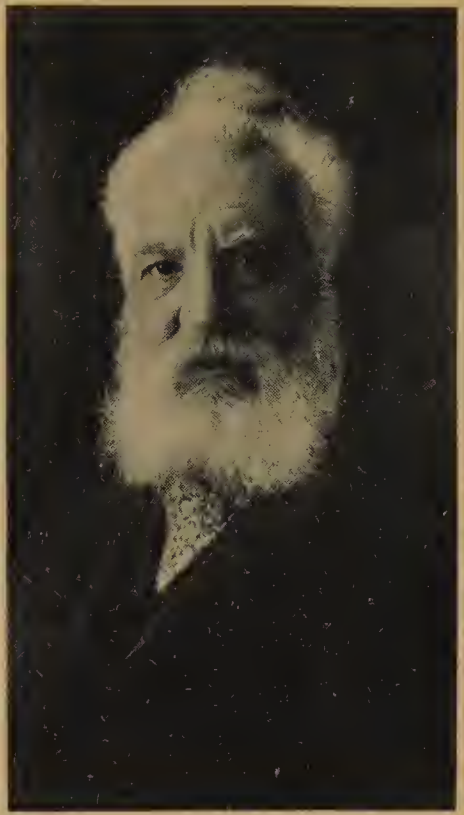
And the telephone romance is far from the end of its journey. The future is big with promise.

Not long before his death, Bell said, "I confess I do not understand tonight how a man can talk in Arlington across the river from Washington, and a man in the Eiffel Tower in Paris hear him. I dare admit I blazed the way, but the great discoveries and development that followed called for the correlation of many minds." And chief among them was that of Theodore N. Vail.

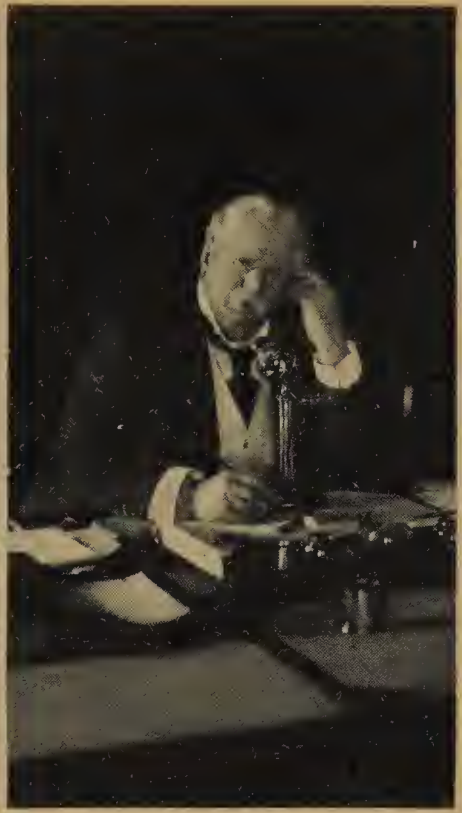
After Vail

On January 7, 1927, the world was almost startled by the announcement that London and New York were in telephone communication. "Hello, London" was no longer a dream. The Atlantic had been bridged by two-way speech. Today, it is no uncommon thing for a telephone subscriber in this country to be told by the operator that Paris or Berlin is on the phone. Business men in foreign capitals ring up their wives. Theatrical managers complete agreements with favorite stars abroad by telephone. When Chamberlain had flown from Long Island to Berlin, he was told, shortly after his arrival, that his mother in far-off Iowa was on the wire and wished to speak with him. Aside from occasional interference from static, the voice carries as clearly and distinctly as though the speakers were separated by no more than a city block.

Daniel Webster, shortly before his death in 1852, predicted that no future period of history would see greater scientific discoveries than those of his own time. He referred particularly to the "miracle" of the telegraph, the



Alexander Graham Bell



Theodore N. Vail

Thomas A. Watson

Courtesy of the American Telephone and Telegraph Company

Behind the scenes in a telephone exchange — a bit of the dream brought to pass by Bell and his associates

discovery of the anæsthetic properties of ether and the invention of the steam locomotive. And yet, practically the whole of what we call the Age of Electricity lay ahead; within a quarter of a century, the telephone was to be invented; radio was to banish isolation; the airplane was to make its conquest; the phonograph, modern photography, moving pictures, talking movies, the motor car, and a host of other important inventions were to take the world almost by storm. Television, the invention which makes it possible to see one's distant friend at the same time that he hears him speak, is here. Although still in the experimental stage, you young readers of this book will beyond question live to see this present-day marvel as much a commonplace as the telephone is now. What would Webster think could he know of all this wonderful progress? It is rash these days to say that anything is impossible. Before it gets into print it is usually out of date.

Theodore N. Vail, of all persons, however, had no idea that the telephone romance had reached "journey's end." Not only did he have General J. J. Carty at the head of his engineering staff, but in Dr. Frank B. Jewett, at that time Director of Research in the Bell Laboratories, he had a man whose vision included big things. At the large building on West Street in New York, where these laboratories are housed, Dr. Jewett commands an army of two thousand trained scientists, aided by more than that number of assistants. He is now president of this branch of the service and a vice-president of the larger organization. Upon his decision rests the spending of millions of dollars in research. Transatlantic telephony and television have

been brought to success under his direction. He is helping in a big way to bring to pass the dreams of Vail and his associates. In short, Dr. Jewett is a tremendous factor in the success of one of the biggest business organizations in the world today.

Although coming from New England ancestry, Jewett was born at Pasadena, California, a little more than a half century ago. He attended what is now the California Institute of Technology, and afterward studied under Professor Michelson at the University of Chicago. With such a master, no wonder that he became a great engineer. His father, too, had been a civil engineer and the builder of the California division of the Santa Fé Railroad. After obtaining a doctor's degree at Chicago, Jewett came East, where he taught for a time at the Massachusetts Institute of Technology, and then joined the forces of the telephone organization.

Fortunate indeed was Vail in having so able a lieutenant to carry forward the research work essential to the future of his great undertakings.

A Fortune in Sunbeams

The other day, I saw a moving picture in natural colors. It was as life-like as though I had looked upon the scene itself. I saw a little girl with her dolls and carriage on the lawn beneath the spreading branches of a beautiful tree. Her lips were red; her hair was golden; leaves and grass were green. Quickly, the view changed. Sparkling waters, broad landscapes, delightful bits of nature, people, life, the energy and charm of a living, throbbing world in

rapid succession passed before my eyes. And as I looked, I knew that a dream had come true. Once more an idea had traveled the route from an inventor's brain to a mechanism that did his bidding. The sunbeams had been made to paint their pictures in colors on a movie screen.

"What of the man who made this dream come true?" you ask. I do not believe I need to tell you his name. You have already guessed. A generation ago, when your fathers and mothers were school boys and girls, he discovered a way of bringing the camera into every home. He made it possible for anyone to trap the sunbeams and reproduce the picture that they bore. He invented the "Kodak" and coined the name. In 1890, at Kodak Park, near Rochester, New York, he started a plant, which today numbers seventy buildings, covering four hundred acres of ground, and employs nineteen thousand people. The paper mill alone occupies nine acres, and each year this plant turns out about two hundred thousand miles of motion picture film, besides plates, films and cameras by the thousands. You know now that I mean George Eastman.

I know, too, that you want to learn more about this man. In particular, you wish to know about his boyhood and how it happened that he has been able to build a fortune from sunbeams, a fortune which has enabled him to give away for the benefit of others almost as many million dollars as he is years old. In the summer of 1929, he celebrated his seventy-fifth birthday.

When Mr. Eastman was less than a year old, his father died. The father had started the first successful business college in the country, but it did not survive long after

his death. The little family, mother, son, and two sisters, were facing poverty. At fourteen, the boy left school and went to work in an insurance office at three dollars a week. Besides clothing himself and helping his mother, he saved and put in the bank $37.50 that first year. That was his first capital, and this was before he had begun to dream of putting the sunbeams to work for him. It was not long until he was earning $600 a year, quite a good salary for those times, about 1870. Then, his employer recommended him for a position as bookkeeper in a savings bank at a salary of $1000. He was forging ahead, and he was dreaming dreams. What boy or girl does not?

A dream of young Eastman's was to be able to travel. One summer, the bank gave him a vacation, and he decided to take a trip to the West Indies. His mother, who was not well, could not go with him, and he wished to bring back to her pictures of what he saw. He paid five dollars to a Rochester photographer for instructions in the art of taking pictures. But this was a prodigious task in those days. You can have no idea of the cumbersome outfit and the tedious operations required. To take a single picture was a half day's work, and there was no certainty that the result would be a pleasing one. Eastman decided that all this should be made simpler. And he saw, too, that there might be a fortune in the doing of it. Thus, one dream led to another.

The wet-plate process was then the only one in use. Before exposure, the plate must be dipped in the dark into solutions prepared at the time and slipped into the camera dripping wet. The photographer must carry his dark room with him and develop the exposed plate on the

spot. As he fared forth, he looked much like a traveler starting on a journey to a far country. Needless to say, there were few amateur photographers in those days.

This was the situation when young Eastman learned of a new dry-plate process, which had been discovered in England. You may well believe that he seized upon this bit of news with eagerness. His experience in the West Indies had taught him that some such process must be invented if the art of photography was to become common, and he was already an enthusiast for this idea.

His first move was to read everything he could find on this new process. Then he began to experiment. That is the only way in which discoveries of this sort can be made. He was still at work in the bank, and his salary had been increased to $1,400. Urged on by this fascinating idea, he turned his hours after work and his evenings to account. He hired a room for a workshop. Soon, he found so much to do that he needed an assistant. This led to hiring a young man to mix solutions and make preparations of materials for his use after banking hours. Gradually, this hobby began to absorb his entire interest. Sometimes, he did not go to bed all night. The only sleep he got was an occasional nap while his chemicals were in preparation.

The foundation of the process he was developing seemed to be gelatin. An emulsion of this substance with the light-sensitive chemicals was the starting-point. The trick was to get the right mixture and the proper physical and chemical conditions. Young Eastman was groping largely in the dark. He was not a chemist, and he had received no scientific training. Bell once said that, had

he known more about electricity and less about sound, he should never have attempted to invent the telephone. Maybe, if Eastman had been more of a chemist and less of an enthusiast about pictures, the idea of a camera-world would not have been born. But failures did not daunt him. He knew that failures are the stepping-stones to success. If this new idea, coming from England, promised to give a simpler way of taking pictures, he believed that he could discover the secret and improve the method.

After two years, he succeeded. Of this happy moment in his career, he once said, "I just happened to hit upon a good formula; it was more or less luck." Still, such "luck" seems to have a way of coming to those who are qualified to receive it. No one imagines that young Eastman would have discovered the secret of dry-plate photography if he had not been headed in the right direction.

For a time, this self-made manufacturer continued to work in the bank by days and to carry on his hobby in outside hours. But the business grew, for his plates were by far the best of any that could be found on the market. The photographer who had taught him how to take pictures for his West Indies trip was his first customer. Then, a photographic dealer in New York learned of the superior plates. He immediately placed an order for a certain number every month, including the slack months of winter as well as those of summer. The business of the thriving firm now amounted to about $4,000 a month. Of course, this was by no means all profit, but it enabled Eastman to resign from the bank and give all his time to the little factory he had established.

Spring came and with it a seeming catastrophe. He was overwhelmed with the complaints pouring in regarding the poor quality of the Eastman plates. Undismayed, he hurried to New York to discover the difficulty. It was all too true. Plates which had stood for several months had lost their delicate sensitiveness to light. Eastman himself could not make good pictures from them. In some way, the gelatin seemed to change with age. Baffled, but not defeated, he returned to Rochester.

His first move was to take back every poor plate that he had sold. It nearly ruined him financially, but he knew that he could not found a business upon any other than a reputation for fair dealing.

Bad as all this was, worse was yet to follow. Not only did his plates become worthless with age, but he could no longer produce a good plate at all. Fortune ceased to smile upon him. His formula would not work. Try as he might, he could not make a good light-sensitive plate. Day and night, he worked to discover the reason, but it was all to no use. He closed the factory that had promised so much. It was only a waste of money to produce an article that could not be marketed, and Eastman had no money to lose. This was in 1881.

Discouraged and bitterly disappointed, but not beaten, this young man of twenty-seven shut up shop and sailed for England. Going to the best firm of plate-makers abroad, he bought their formula and spent two weeks in the factory learning every detail of its use. Then, he returned to America and set his own factory in operation once more. It has been going ever since and growing with each succeeding year.

Before going further, I imagine you would like to know why his own formula failed to work. It was due to the gelatin. His first success had been made with a certain lot of gelatin, and when that was gone he could get no more exactly like it. There was something about that first lot which made it different. As Mr. Eastman has said, it does seem like luck that he should have stumbled upon just the right kind of material for those early experiments. Without that happy accident, he might never have gotten started.

With the dry-plate process an assured success, Eastman turned to the development of the camera itself. He knew that a big market for his product lay in making everyone a camera enthusiast. So long as only the professionals made pictures, he could not hope for a big business, as we think of big things now. He wanted to make the art of photography so simple that anyone anywhere could succeed in it. He himself had tasted the fascination of it, and he knew that he had only to point the way to make thousands as eager about it as he had been.

Four years had passed since his return from England and Eastman had already invented a flexible roll-paper film. Then, he made a camera especially adapted to its use. He sold these cameras loaded with a film containing one hundred exposures. Anyone could snap them, and when the whole number had been used, the camera was returned to the Rochester factory. There, in a dark room, the film was taken out by experienced workers and developed. As many prints were made as the owner desired. Some of you, in looking through old magazines, may have seen Eastman advertisements with the caption, " You press

(*Above*) George Eastman and Thomas A. Edison

(*Below*) Dr. C. E. K. Mees, Director of the Eastman Kodak Research Laboratories

Theodore William Richards
A great chemist

Dr. William H. Nichols
Pioneer in the field of chemical industry

the button, we do the rest." You now know what that meant.

Mr. Eastman wanted a unique and interesting name for his new invention, and he coined the word Kodak. I venture to say that no other similar word in any language is better known than this. It has made its way into every country on the globe, for people everywhere, just as the boy Eastman predicted, like to take pictures.

Still, Eastman had won only partial success. It was awkward to have to send a camera all the way to Rochester. One did not like to be without it for several days or a week. Many amateurs wanted to do their own developing and printing. But a new type of film was necessary, and this Eastman proceeded to invent. He employed a young chemist and told him his ideas for a thin transparent film. From guncotton, or nitrocellulose, and alcohol, they prepared it. Incidentally, this discovery of a film through which light will pass enabled Edison to perfect the motion picture machine.

Eastman now began sending out cameras to hold as few as a dozen exposures. All the while his plant had been expanding. Hundreds of new workers had been added. Kodak Park was a rapidly growing suburb of his home city.

Other successes along the way were a camera and film which did not require a dark room for loading, the developing machine, the autograph Kodak, and constantly more sensitive films. I presume there is not a reader of these pages who has not benefited from this realization of a boy's dream.

But such a man as George Eastman never ceases to

dream. Not long ago, the idea of motion pictures in colors captured his interest. How well he has succeeded the first paragraph of this sketch tells you. In the summer of 1928, he announced his achievement. Now even amateurs may make color films and project the scenes on the screen. What his next dream will be, we can not say, but we may be sure that the man who showed everyone how to make the sunbeams paint his pictures has something more in store for us.

I CAN not leave this sketch of the founder of Kodak Park without telling you of his most useful assistant. You who enjoy the new luxury of motion pictures in the home are already acquainted with his work. His name is C. E. Kenneth Mees, Director of Research in the Eastman Laboratories.

When in 1912 Eastman wished to establish laboratories in which to study in a more scientific way the art of making pictures, he went to England to secure Dr. Mees to direct the work. Mees, then at the age of thirty, had become known as the research genius of Wratten & Wainright, a British photography house. Whether or not it was his purpose to make it simpler to obtain the services of Mees, Eastman's first step was to purchase the business of the British firm. Then, he persuaded Mees to come to Rochester and organize a laboratory. Mees had already visited Rochester, and apparently this was not a difficult task. Anyway, he came, and he has been there ever since.

While still a lad, Mees decided upon a scientific career. His father, a Wesleyan minister of Wellingborough, England, sent him first to a technical school for boys and

afterward to the University of London. There, it was his good fortune to study under Sir William Ramsay, one of the greatest scientists of recent times. Becoming interested in photography through the enthusiasm of a brother for the fascinating pastime, he took up the chemistry of the subject. Here was a new field. Little was known regarding it. If photography was to become a science, someone must do the pioneer work. When he was only twenty-one, he and a fellow student, named Sheppard, now with him at Kodak Park, published a paper on photography which won for each a doctor's degree and made them known as leaders in this new field.

A little later, Mees went to work in the laboratory of Wratten & Wainright. Soon his discoveries were bringing him recognition and honors. Three medals were bestowed upon him, and he was called to America to give advice regarding the color printing of securities. Then it was that he visited Eastman and formed the acquaintanceship which led to the invitation to become a resident of our country.

Not long ago, it was my pleasure to hear Dr. Mees give an address at a luncheon in New York. No one who has heard him can ever forget the charm of the man and his delightful way of telling of scientific discoveries. One can understand, too, why he is so well beloved by his assistants and his brother chemists in America. He stands in the forefront of his profession. No chemical gathering is complete without his presence. Without him, the big developments in photography of recent years would still be in the future. Movies in colors are largely the result of his work. And Dr. Mees is still a young man, even yet

almost boyish in appearance. In the years to follow, we may expect much more from his brilliant work in the field of photography.

Journalism Finds a Master Builder

A LITTLE more than a half century ago, when horse-drawn cars on city streets were the fastest means of travel, a clever Brooklyn lad of twelve years might have been seen selling ice-cold water at a penny a glass to the thirsty passengers, at a certain watering place where the horses were allowed to drink. On Saturday and Sunday afternoons, the days on which he was not in school, he was able to net a profit of six dollars from the brisk business that he did. Anything so profitable as that could not long go unchallenged. Soon, this industrious lad had a competitor; then several. Immediately, he met the situation by squeezing a half dozen lemons into each pail of water, adding a little sugar, and selling lemonade at three cents a glass. Instead of diminishing, his profits grew.

This boy was Edward Bok, the son of a Dutch immigrant, who had arrived in 1870 with his family to make his home in this country. Unfortunate investments in the homeland had swept away the father's property, and he had come to America for a new start. However, prosperity did not easily come, and young Edward found it necessary to help in every way he could. Before and after school he helped his mother, but he did not think this enough. The family needed money, and he felt certain that there must be some way in which he might earn it.

One day, in passing a baker's shop, he noticed that the windows needed cleaning. Entering the shop, he offered to clean them. So good an impression did he make that the proprietor engaged him on the spot to do the job twice a week at a fee of fifty cents. This was a good start, but a half dollar a week, even in those times, would not go far. Soon he made another opportunity. One day, after cleaning the windows, he found himself alone in the shop, the baker having gone out. He made bold to wait upon a customer. Before he was through the proprietor returned and, noting how skillfully he did up the packages, offered him a dollar a week to stand behind the counter after school hours and wait on customers. On Saturday mornings, he tended a paper route, and in the afternoon of that and the following day he sold lemonade to the passengers on the horse cars. Surely, a boy with so great energy and determination was bound to succeed, and he did. He built one of the biggest journalistic enterprises in the world.

At thirteen, Edward Bok asked his father to be permitted to leave school and take a position as office boy with a telegraph company. Consent was given, and the lad, old for his years, found himself a wage earner in a big city.

Of course, he had no idea of remaining long as a mere office boy. As a first step toward bigger opportunities, he decided to study the lives of men who had been successful. In the public library, he found a book of biography, giving just the information he wanted. Determined to possess it for himself, he saved money by skimping his lunches and walking five miles each way to and from

work. The book was soon his. It was a great satisfaction to learn that most of these men at the start had been poor like himself.

Fascinated with the lives of these great people, Bok began writing to them. From many of them, he received replies, making a treasured collection of both the letters and their autographs. In a short time, from his reading and his letter writing, he was in possession of much information regarding many great personages.

This knowledge brought his next opportunity. In those days, cigarette packages contained cards having on one side the picture of some distinguished person. One day, Edward picked up one of these cards in the street. He noticed that the back of the card was blank. This seemed to him a waste of good space. How much better it would be if this space should contain a little biography of the person whose portrait was on the other side. Immediately, he called at the office of the company and explained to the manager his idea. Being an original idea of undoubted merit, it was gladly accepted, and young Bok was given an order for a hundred such biographies at ten dollars apiece. Then, he was given orders for a second hundred and a third. Here was real money. Soon, he had his brother and two paid workers gathering material for him. While still only a boy, he had become a successful employer.

At two evening schools, Bok now began the study of shorthand. He had decided to become a journalist, and he knew that this art was indispensable to successful reporting. Already, he had had a taste of this work. Invited to a party, he had written an account of it, giving

the names of all those present. This, he had offered to a local paper, which readily bought it at the rate of four dollars a column. The editor had also asked for more such material. Exciting business, this was, and it appealed to the imagination of this Dutch lad in a new country.

Before long, a really big opportunity came Bok's way. The editor of the paper asked him to report two addresses before Brooklyn audiences, one of which was to be given by the President of the United States. Finding that his skill in shorthand was not sufficient to enable him to take down all that the President had said, he sought him out afterward and explained how much this assignment meant to him as a reporter. As a result, he was given a complete copy of the address, and he had the satisfaction of knowing that his paper was the only one that carried it in full. This was a real triumph.

Not content with merely writing to the great, Bok now went on a visit to Boston, where he met and talked with such distinguished people as Henry W. Longfellow, Oliver Wendell Holmes, and Ralph Waldo Emerson. A great privilege that was. Who would not now wish to be so fortunate? For a time, he devoted his evenings to editing a church magazine in Brooklyn, and these acquaintanceships were valuable to him in securing material for publication.

Many of you are familiar with the little articles, written by some particular person and occurring daily in most newspapers. Some of you know, too, that any given article appears in a large number of papers in different parts of the country on the same day. Supplying articles in this way is known as "syndicating." In Bok's early

years, this practice was almost unheard of. The idea looked good to him, and he decided to capitalize it. Opening an office in New York and employing his brother as partner, he began sending out a page devoted entirely to women's interests. Here, too, was another novel idea. No one before had thought it worth while to pay much attention to matters concerned only with the home and feminine affairs. Bok saw the opportunity and was quick to seize it. Not only did it prove to be a success, but this venture served as an excellent preparation for his later career as a journalist.

Now came an opportunity to join the publishing house of Charles Scribner's Sons as stenographer. Before long, he was promoted to the advertising department and still bigger things. In addition, he began syndicating a weekly book feature and selling it to forty-five papers. And Edward Bok was just past twenty-one.

One of the publications using his book feature was the *Ladies' Home Journal,* then far from being the large and influential magazine which we know today. Its owner, a Mr. Curtis, was in search of an editor and decided to offer the place to Bok. Ambitious though he was, Bok was well established in New York. He had a good position and abundant opportunity to employ his journalistic talents in spare-time activities. He hesitated. Many advised him not to leave a sure thing for an uncertainty. But, after careful consideration, he decided that the road toward larger opportunities lay in Philadelphia. He accepted, and that decision, together with hard work, made him one of the greatest journalists in the world.

For thirty years, Bok guided the fortunes of this publication, seeing it constantly grow in influence and popularity. He saw its circulation mount from less than half a million copies a month to nearly two million. And that is big business. Into it, he never ceased to build new ideas — original, vigorous, and throbbing with human interest. He invited his readers to write to his staff of experts for information upon any subject which interested them. At the beginning of the Great War, such requests had reached a million a year, and the *Ladies' Home Journal* stood, as it does yet, at the very front of women's publications anywhere in the world.

At fifty-six, Edward Bok retired. He had accomplished as much as most of us would in a half dozen lifetimes. He tells us in his book, *Edward Bok: An Autobiography,* that he never worked by the clock. The accomplishment of the job in hand in the best manner possible was always his goal. That was a secret of his success. To it, he added great ability and a remarkable degree of energy. Keen, alert, quick to seize his opportunities, this self-educated Dutch immigrant rose to a position in the world of journalism and big business which for many a day will shine as a beacon light across the coming years.

A Pioneer of the Chemical Age

Before closing this chapter, I wish to give you a glimpse of a pioneer in the field of industrial chemistry, a builder of big business enterprises, essential to the national welfare both in peace and war. He is Dr. William H. Nichols of New York, and until his death early in 1930, one of the

two surviving men present at the organization of the American Chemical Society in 1876.

A few years ago, it was my pleasure to visit the Nichols' copper plant in Brooklyn, N. Y. It was in war time and before me, covering a large area, lay a king's ransom and more in huge ingots of copper metal brought thither from many distant mines to undergo the process of refining. Many years before, a man had brought to Dr. Nichols samples of ore from a mine in Canada. It turned out to be a combination of iron and copper pyrites. All of you remember the story of the Spaniards who, shortly after the discovery of America by Columbus, filled their ships with "fool's gold" and carried it back to the old country. Well, "fool's gold" is iron pyrites. It contains sulfur and is used in the manufacture of sulfuric acid, a business in which Dr. Nichols was at that time engaged. He bought the mine and began the separation of the copper in an impure form, known as "copper matte." This product had to be refined, and Dr. Nichols sold it to the refiners. At length, there came a day when the refiners refused to take any more of his matte. The young manufacturer seemed to be face to face with a near catastrophe. His competitors had combined against him.

Nevertheless, Nichols was equal to the emergency. If the refiners of copper would no longer accept his product, he would refine it himself. Bringing to America for the first time the electrolytic process of refining, he began the building of what grew into one of the world's largest refining plants. And in the process, he obtained gold and silver as by-products, for the precious metals usually exist as "impurities" in copper ore. In a short time, he had

revolutionized the industry and had placed himself at the head of the copper refiners in America.

Another incident shows the sort of man Dr. Nichols was. While not yet of age, with his father's help, he had built a plant in Brooklyn for the manufacture of sulfuric acid. There, too, his rivals combined against him, entering into an agreement to fix prices at a figure which robbed the young firm of its orders. Financial ruin seemed certain, and then of a sudden the picture changed. Dr. Nichols has told the story himself. He says, "When I began making this acid, I found that, although all the sulfuric acid on the market was labeled as sixty-six degrees, much of it was under strength, usually only sixty-five degrees. I made mine sixty-six degrees and marked it accordingly. Before long I was waited on by a body of my competitors, who declared to me: 'You are making a fool of yourself. You are only a young man and new at the business and perhaps that's why you don't seem to know that you are incurring unnecessary expense to yourself by making your acid sixty-six degrees when sixty-five degrees is just as good.' I told them that if I made sixty-five-degree acid I must put 'sixty-five degrees' on the package and that if I put 'sixty-six degrees' on the package I must make sixty-six-degree acid. They went off very much dissatisfied and disgruntled.

"About this time the process of refining oil was discovered and orders for sulfuric acid poured into us faster than we could fill them. But though we were swamped with demands for our product, our competitors were not. Of course they set about finding out the reason why, and they discovered, as the oil refiners had already discovered,

that sixty-five-degree acid was not strong enough for refining oil, whereas sixty-six-degree acid met every requirement."

In the 'sixties of the last century, Dr. Nichols was a schoolboy in Brooklyn, attending the very school in which I myself have for many years been an instructor. From there, he went to New York University, graduating with a B.S. in 1870 and three years later earned an M.S. When only eighteen, under the name of Walter and Nichols, he began his career as a manufacturing chemist. Since he was not then of age, his father became the financial partner of the little firm. Soon, Mr. Walter was killed in an accident, and the entire management of the business fell upon young Nichols. He was at the same time chemist, superintendent, office manager and salesman. This was too much, and he found a factory manager to assist.

Dr. Nichols was a pioneer in a new field. Industrial chemistry, now of such immense proportions, was only in its infancy. Just as Sir William Perkin, the youthful discoverer of coal tar dyes, had been compelled to do, Nichols found it necessary to design equipment, invent processes, and blaze new trails. More than anyone else, he was the founder of the chemical industry in America. As president and director in big enterprises, for more than half a century he engaged in introducing new discoveries, building industries and making his country independent of foreign sources of supply.

The name of Dr. Nichols and his achievements are known in Europe as well as in America. Foreign rulers, learned societies and universities in many lands have

honored him. His friends were everywhere. And with it all came wealth, making it possible for him to dispense gifts to education and charity with princely generosity. And he gave of his time as well as of his money. For many years, he was chairman of the board of trustees of the Polytechnic Institute in Brooklyn, performing a service to scientific education of great importance. In the field of chemistry, Dr. Nichols was America's foremost captain of industry.

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